Dynamic Transfer Limit Study Methodology

Assessing the Impact of Dynamic Transfers on Transmission System Operation

Draft Report

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Study Performed by

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Executive Summary

Dynamic transfer is the means by which the electrical output of a generating resource is controlled in real-time by an entity other than the Balancing Authority in which the resource resides. While providing greater operational flexibility, it requires that adequate provisions are made for the effect of real-time variation on the transmission system.

The Dynamic Transfer Limits Study is one of five Wind Integration Team projects BPA committed to in 2009. Working in conjunction with the Columbia Grid Wind Integration Study Team, the purpose of the study was to develop a credible, quantitative methodology to assess the impacts of dynamic transfers on the BPA transmission system.

This study evaluated transmission reliability impacts resulting from increased dynamic transfers across major PNW transmission paths and established the portion of the existing transmission capability available to accommodate dynamic transfer. Specific concerns identified in the study include the effect of rate of change on voltage management and stability, system operator workload, and switching duty for reactive elements. This study describes a methodology for assessing these factors and quantifying their effects on the transmission system.

Currently no established method is available in the literature to calculate Dynamic Transfer limits for multiple paths. This study proposes the use of linearization techniques to account for the effect of dynamic transfer on system voltages and optimize the problem to address simultaneous interactions.

Several scenarios were evaluated using the proposed techniques. The goal for this phase of the study was to establish a systematic method for determining dynamic transfer limits, and set initial dynamic transfer limits such that system operation was not significantly affected. These limits will in turn provide a baseline for determining the system improvements necessary to accommodate increased use of dynamic transfer in the future.

The initial dynamic transfer limits established by this study are:

Name	**Studied Dynamic Transfer Limit** (may be reduced by system conditions)
COI	**500**
NORTHWEST - CANADA	**300**
MONTANA - NORTHWEST	**110**
IDAHO-NW	**200**
NORTH OF HANFORD	**320**
NORTH OF JOHN DAY	**350**
SOUTH OF ALLSTON	**300**
WEST OF CASCADES - NORTH	**320**
WEST OF CASCADES - SOUTH	**280**
WEST OF MCNARY	**150**
WEST OF SLATT	**150**

1.0 Introduction

Dynamic transfer is the means by which the electrical output of a generating resource is controlled in real-time by an entity other than the Balancing Authority in which the resource resides. While providing greater operational flexibility, it requires that adequate provisions are made for the effect of real-time variation on the transmission system.

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There are two attributes of dynamic transfers, particularly when associated with geographically remote variable generation resources, which impact the transmission system:

- Variability: The amount (rate and magnitude of change) plant output fluctuates in the time scale significant to real time operations.
- Uncertainty: In the context of the tools and data available to the dispatcher, plant output fluctuates unpredictably in the real time operations time scale.

While much of the wind generation on the BPA system has been developed in the Lower Columbia region, dynamic transfers project the variability and uncertainty of wind projects to other areas of the transmission system. The region as a whole must insure that dynamic transfers can be utilized without adversely affecting reliability.

Reliability Concerns: While dynamic transfer is being used now, previous experience with this mode of operation raises the concern that extending the variety and location of resources used may pose threats to the reliable operation of the grid. The conventional methods used to assess reliability impacts (planning and operations) are not sufficient. The management techniques used to prevent, detect, and correct issues resulting from voltage sensitivity, effects on operating limits, and response to contingencies must also be improved before fully realizing the benefits of dynamic transfers without detriment to reliability.

Operational Concerns: Care must be taken to reasonably assure that system operators have the tools, skills, and information for real time operations. BPA dispatchers have manual control of several functions (e.g. RAS arming and switching) and increased dynamic transfers may increase workload and the skills required of the operators. Also, there may be a need for fundamental changes to the current mix of manual and automated controls. The effect of rapidly changing flows are likely to impact other PNW systems as well, possibly requiring greater coordination of procedures, voltage control, and other real-time activities by system operators of neighboring utilities.

This study evaluated transmission reliability impacts resulting from increased dynamic transfers across major PNW transmission paths and established the portion of the existing transmission capability available to accommodate dynamic transfer. Specific concerns identified in the study include the effect of rate of change on voltage management and stability, system operator workload, and switching duty for reactive elements. This study describes a methodology for assessing these factors and quantifying their effects on the transmission system.

The PNW interconnections examined in this study are:

- BCTC-BPA
- COI
- West of Garrison
- Northwest to Idaho (La Grande)

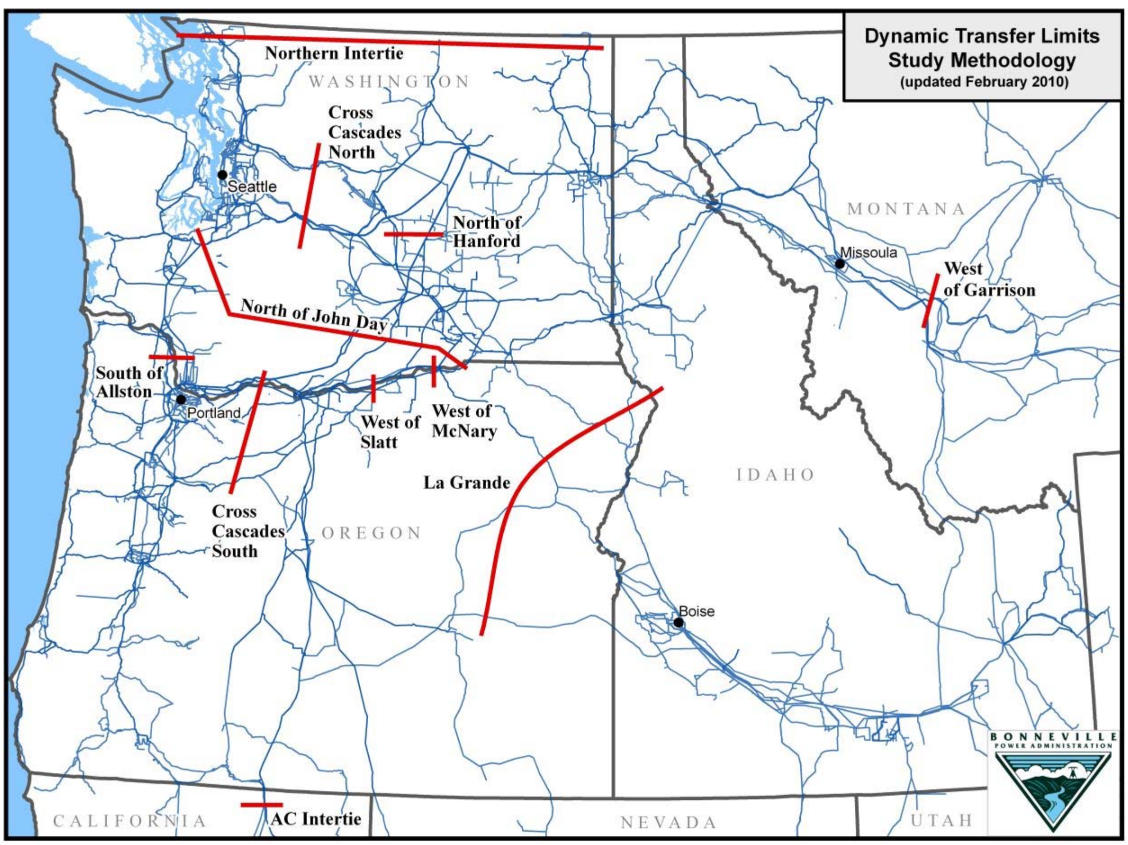

Figure 1: PNW Interconnection and Flowgates included in Study

Internal paths considered in this study include those bordering wind generation areas or otherwise affected by flows resulting from dynamic scheduling across the interties:

- South of Allston
- Cross Cascades North and South
- North of John Day
- North of Hanford
- West of McNary and West of Slatt

The close coupling of these paths to each other, and their combined effect on voltages within the BPA system, requires an approach that takes the interrelationships into account and faithfully represents how dynamic transfer, implemented on a system wide basis, effects grid reliability as a whole.

The grid and its controls were designed for system conditions that were largely static, where with the exceptions of ramp periods or contingencies, the only significant variation was a result of load following. Dynamic transfers challenge this fundamental assumption and make it clear that the old control strategies, largely manual, are not sufficiently flexible to accommodate unrestricted expansion of dynamic transfer. Next steps should include identifying where reinforcement, both to the grid and its control mechanisms, is necessary to expand the capability to operate with the increased implementation of dynamic transfer.

2.0 Problem Definition

Dynamic transfers are a special allowed use of existing transmission capability (e.g. the ability to ramp continuously within the hour). As such, they are intended to always operate within the existing nomograms. Current methodologies for system operating limits find the boundaries of operation only, and are designed to find the most limiting cases based on a set of extreme criteria. As a result, the current methodologies and criteria are not suitable for evaluating the effects and limitations to operation within the nomogram.

Real-time concerns for dynamic transfer can be categorized in terms of Direct Effects and Indirect Effects.

- Direct Effects are those where electrical parameters interact: MW, MVAr, voltage, and topology (e.g. Ohm's Law). Quantifying direct effects implies the development of methods and criteria to measure how voltage will vary with path loading, area load, and reactive support from nearby machines.
- Indirect Effects are those where the electrical changes resulting from dynamic transfers require operator actions, or decisions, to take place. These are largely related to the ability of system operators to maintain situational awareness and adequate operational control of the transmission system while generation and critical path flows are subjected to a continuous ramp that may be outside of their direct control. Quantifying indirect effects implies the development of methods and criteria to measure how increased switching duty on reactive elements, RAS arming, and committing of additional dynamic voltage support effects costs and, if not kept up with, reliability.

A new methodology and criteria therefore must be developed that takes into account these concerns. It must also be capable of being generalized and extended to the analysis of all critical paths.

The goal of this study is to identify a frame work that can be expanded to multiple paths and also capable of including different security constraints as needed to maximize the Dynamic Transfer Limits for multiple paths. The first step in this approach is to establish a method and criteria that quantifies the dynamic transfer that can be accommodated without reinforcement or changes to current operating controls or policies. Given that the central concerns are related to the system operator ability to maintain situational awareness, a baseline criteria must stipulate that no additional manual control actions would be depended on to manage dynamic transfers. Future studies will examine expanded use of dynamic transfer while identifying the necessary automatic controls to maintain reliable operation.

3.0 Methodology

3.1 Background

It is well known that bus voltages are impacted by changing path flows and current system conditions. When the power is transferred from a source to sink it can go through multiple paths and will impact those paths accordingly. (For example, transfers originating with the wind generation in the Columbia Gorge will affect many paths internal to BPA as it serves PNW load centers.) During real-time operation, transmission system operators must manage multiple transfers, and the resultant effects, simultaneously.

There are multiple paths that interact with each other through the effect on bus voltages within the PNW system. It is not an easy to decouple one path at a time and identify transfer limits for each path independently without considering the impact of others. A strategy is needed which maximizes the dynamic transfer for the system as a whole, not for specific paths in isolation from each other.

Currently no established method is available in the literature to calculate Dynamic Transfer limits for multiple paths. The methodology proposed here uses linearization techniques to account for the effect of dynamic transfer on system voltages and optimize the problem to address simultaneous interactions.

Formulation uses the sensitivity of bus voltage to real power transfer through that bus ($\partial V/\partial P$), which can be calculated at all PNW buses. The sensitivity at each bus is calculated for five injection pair scenarios. The maximum injection is then calculated by finding the optimal combination of injection for each specific pair. Since all buses and the five combinations are taken into account at one time, the simultaneous interactions are addressed without undue preference to a specific path.

Two linearization techniques can be used to solve the problem. They are

- Full Jacobin based
- Decouple Based

In this formulation, the Full Jacobin based approach is used. Bus voltage changes are expressed in terms of source and sink injections, and linear programming is used to solve the problem. The results provide a solution where total injection is maximized while respecting voltage constraints for multiple paths.

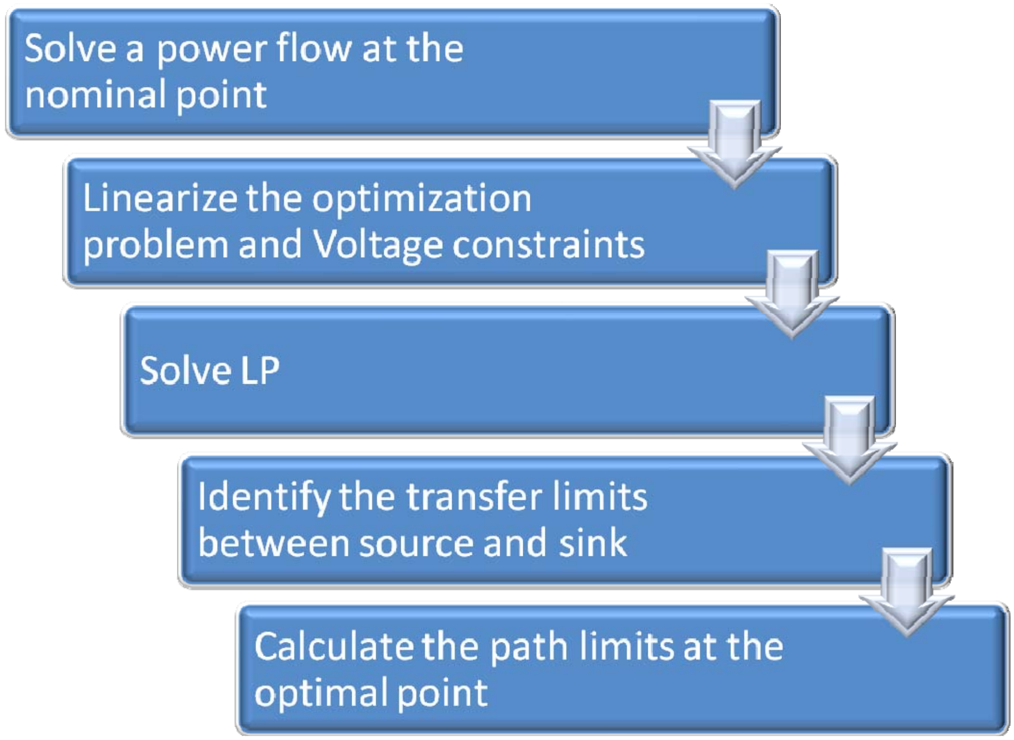

Figure 2: High Level Steps in Dynamic Transfer Limit Calculations

3.2 Assumptions

In the current formulation of the problem following assumptions are made.

- The dynamic transfer limit is voltage sensitive
- The system operating point remains within the current operating nomogram with and without Dynamic Transfers.
- If the system operating point moves out of normal operating nomogram, Dynamic Transfers will be curtailed.
- Line thermal limits and transient stability are not accounted for since the system will operate within the existing operating nomogram.
- $\partial V/\partial P$ linearization is an adequate approximation of the P-V curve within the operating nomogram.
- Linearization is done at the current operating point to calculate the limits. It is assumed that the operating point is voltage stable and that the system is not operating in an extreme range where linearization is not valid.

- Generators in the source and sink areas are capable of providing adequate reactive support for dynamic transfer, and the AVR is on automatic voltage control.
- Dynamic transfers, in themselves, will not require system operators to take continuous manual action to maintain system reliability.
- Reactive devices are locked in the modeling. Switched shunts and transformer tap changers were fixed during the study.
- No additional devices are added to the current system to increase the transfer limits.

Some of these assumptions can be eliminated by adding additional constraints to the problem formulation.

3.3 Injection Pair Scenarios

Computing the ∂V/∂P sensitivity at each bus in the system requires defining a pair of injection points which model a specific power transfer arrangement. For the purposes of this study, the source of the transfer is assumed to be the aggregate wind generation projects located in the Columbia Gorge. The aggregate included wind generation projects located south of the North of John Day cutplane, mainly feeding in to John Day, Rock Creek, and McNary.

From this source, five transfer scenarios were modeled. The sink locations were chosen to stress the paths under study while modeling likely future use of dynamic transfers.

Different locations would result in different solutions because the effect on voltages can be specific to generation causing the change. The proposed formulation takes into account the effect of multiple transfers on the grid as a whole, which mitigates some of the dependency the bus ∂V/∂P sensitivities have to the location of the injection.

While the ∂V/∂P sensitivity can be calculated at any point in the system based on any particular change in transfer (source-sink pair), real-time monitoring requires that the results be expressed in terms of existing critical paths for monitoring purposes.

The ∂V/∂P sensitivity at a bus is the result of the power flow through the bus as a result of the injection. For any MW transfer defined by a specific source-sink pair, the effect of that transfer on a specific path can be determined by calculating the Power Transfer Distribution Factor (PTDF) for that path relative to the injection pair. This allows the sensitivity to be referenced to the MW transfer across the path, rather than to the MW injection at the source and sink.

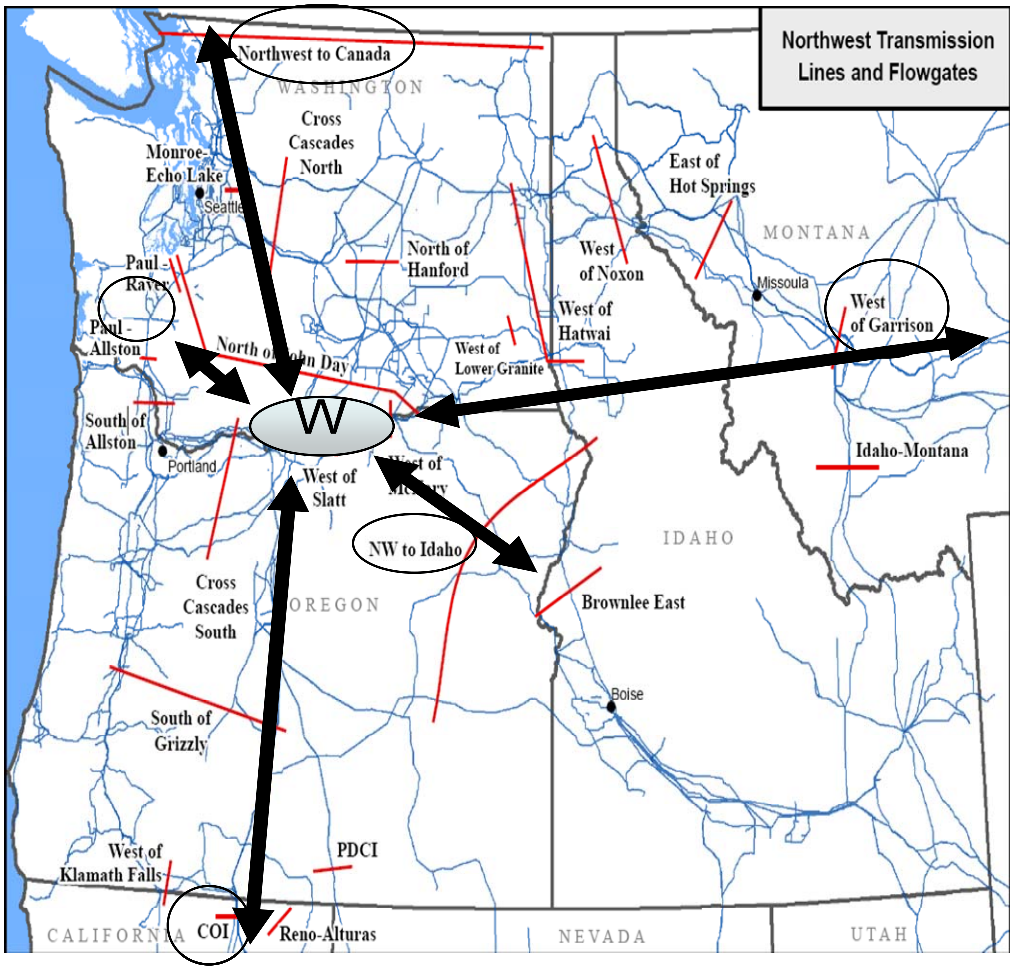

Figure 3: Injection Pair Scenarios

The PTDF for each of the five transfer scenarios was calculated using the "Lossless DC with Phase Shifter Control" option in PowerWorld. This option is consistent with the BPA ATC methodology.

	% PTDF for Various Transfer Pairs (Source: Columbia Gorge Wind)				
Injection Pair Sink:	BCTC Hydro	Bridger	Centralia	Colstrip	N. Cal. Hydro
COI	0.9	18.3	0.5	6.4	92.9
NORTHWEST - CANADA	100.0	0.0	0.0	0.0	0.0
Ingledow-Custer	-100.0	0.0	0.0	0.0	0.0
MONTANA - NORTHWEST	2.3	-20.2	1.4	-81.3	-4.1
IDAHO-NW	-1.4	-61.2	-0.9	-12.3	-1.9
MPSL	2.3	44.6	1.3	11.3	-2.9
NORTH OF HANFORD	-57.6	-10.4	-37.3	-27.4	-3.7
NORTH OF JOHN DAY	-78.4	-24.0	-6.0	-67.1	-5.3
RAVER-PAUL	-15.3	-1.3	34.8	-6.4	1.2
PAUL-ALLSTON	-19.4	-1.7	-49.8	-8.5	1.5
SOUTH OF ALLSTON	-23.0	-2.0	-49.5	-10.0	1.7
ALLSTON-KEELER	-15.6	-1.2	-34.5	-6.8	1.6
KEELER-PEARL	-14.5	-0.9	-31.6	-6.3	2.0
WEST OF CASCADES - NORTH	75.2	-2.1	48.2	-10.4	1.8
WEST OF CASCADES - SOUTH	10.4	1.7	35.8	0.7	6.8
WEST OF MCNARY	-14.1	-12.0	-9.6	-18.8	-3.5
WEST OF SLATT	-4.0	11.2	2.4	-5.3	22.1

Table 1: Transfer Scenario PTDF for Paths included in Study

3.4 Voltage Sensitivities

Transmission system operation is characterized by the relationship of voltage and power transfer known as a PV curve. This relationship can be used as the basis for a linear formulation of the dynamic transfer limit problem.

Since the use of dynamic transfers will be within the existing nomograms, it can be assumed that the region of operation is in an area where the tangential slope is reasonably flat. This is a reasonable assumption because the WECC System Operating Limit methodology results in a path limit that is based on pre-contingency flow and is further reduced by margin appropriate to the contingency. The consequence of this is that calculating the $\partial V/\partial P$ for the operating point provides a reasonably good linear approximation to the effect of changing transfers on system voltages.

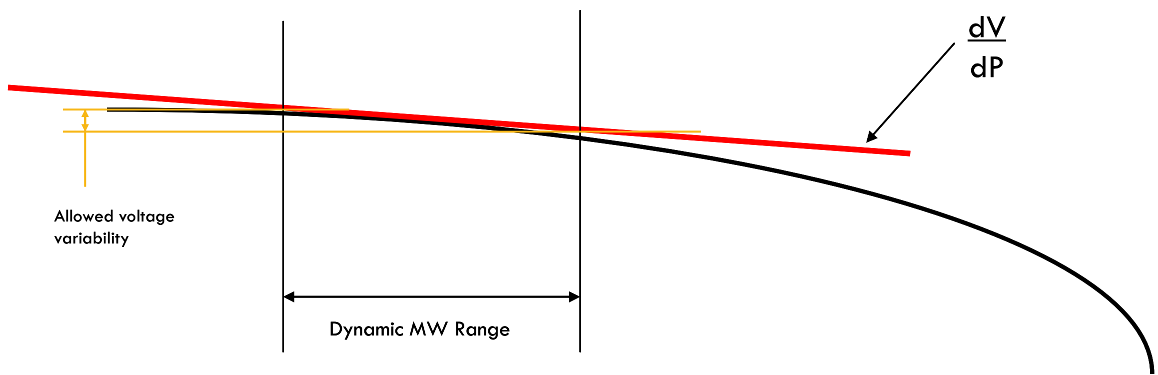

Figure 4: P-V Curve

If a criteria is defined that sets a band for allowed voltage variations, the $\partial V/\partial P$ slope allows the direct computation of the MW range that could be traversed before the allowed voltage criteria is exceeded.

Modeling system conditions over a range of transfers then provides a way of calculating for each specific operating point, the maximum dynamic transfer variability allowed without exceeding the voltage criteria. This provides a more direct means of calculating the dynamic range and an alternative to explicit modeling of the transfer itself.

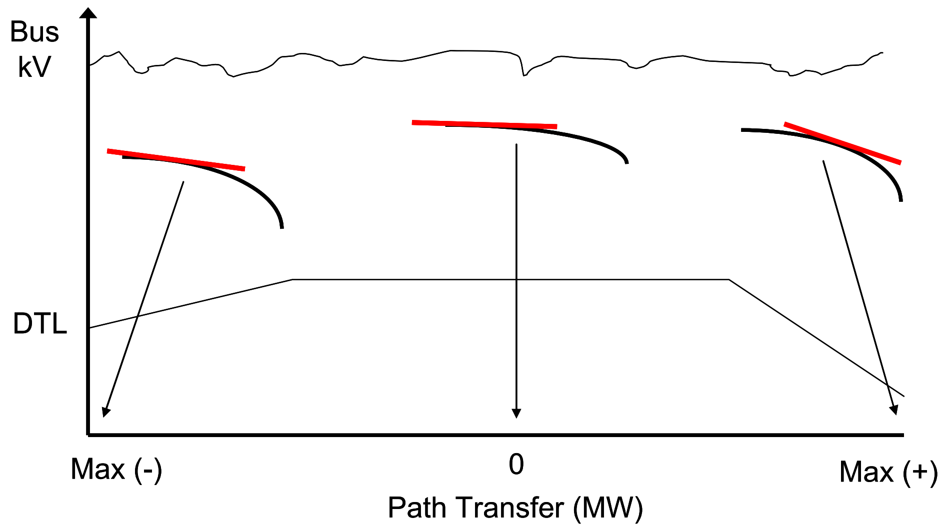

Figure 5: Calculating Dynamic Transfer from ∂V/∂P at Various Operating Points

IEEE standards provide a link between the voltage dip and frequency of dip with respect to power quality seen by the end-user. This relationship can be used to determine a criteria to use for the allowed voltage variability.

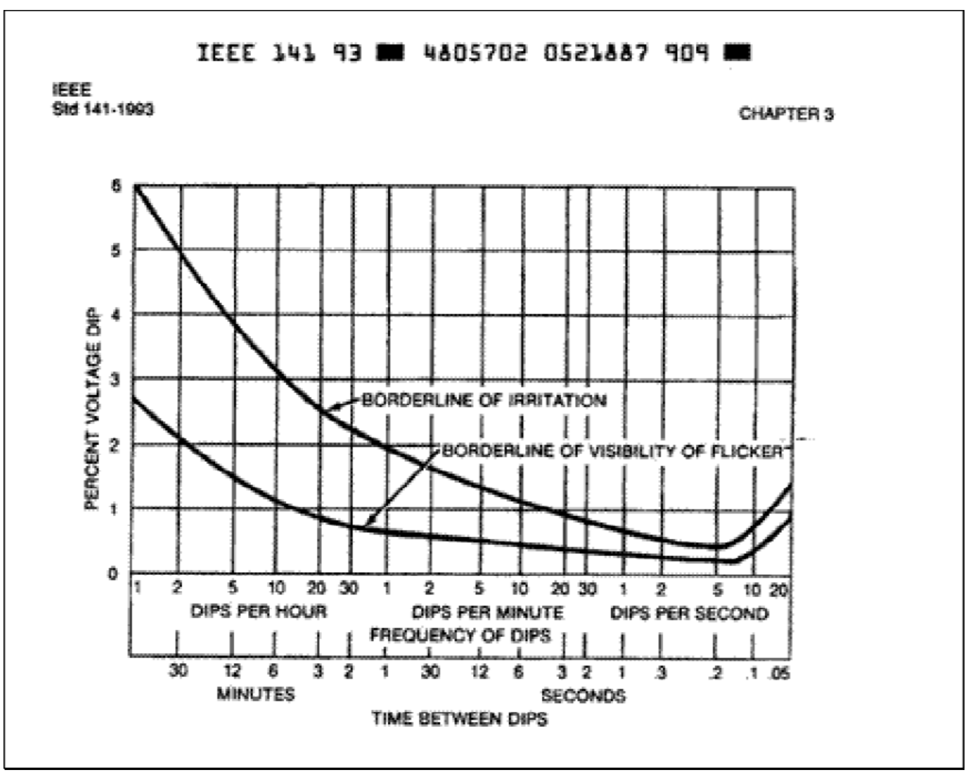

Figure 6: Relationship between Voltage Dip and Frequency of Dip

Dynamic transfers will be used to accommodate shifts in generation sources (such as generation imbalance for wind) that could reasonably traverse the given range of the dynamic limits at least once per hour to several times per hour. Assuming a range for frequency of change to be between 30 min and 5 min, the IEEE standard provides a voltage change threshold of 1% - 2% variation using the "borderline of visibility of flicker" curve. This results in the following criteria:

- The voltages should not change more than 5 kV for 500 kV NW buses.
- The voltage should not change more than 2 kV for 230 kV and 115 kV NW buses

When calculating $\partial V/\partial P$, all manual voltage devices (switched shunts, transformer taps, etc.) are locked. Generators with active AVR will automatically respond to regulated bus voltage and change their reactive output to maintain a voltage schedule, therefore these devices are modeled as a PV bus when calculating the sensitivity.

SVC output at Keeler and Maple Valley was held constant as these devices are intentionally operated near zero output to provide reactive support when needed for contingencies and would not be allowed to provide the full range for voltage management.

3.5 Mathematical Formulation

The purpose of optimization is to schedule power system controls to optimize an objective function while satisfying a set of nonlinear equality and inequality constraints. Mathematically, the problem can be formulated as a constrained nonlinear optimization problem. In this formulation optimization is expressed in continuous nonlinear programming form. Optimal steady state is achieved by adjusting the available controls to maximize an objective function subject to specified operating and security requirements. Historically, different solution approaches have been developed to solve these classes of the optimization problem.

The optimization problem can be formulated as:

Maximize

$f(u,x)$

Subject to

$G(u,x) = 0$

And

$H(u,x) <= 0$

Where:

u	is the set of control variables
x	is the set of dependent variables
$G(u,x)$	is the equality constraints
$H(u,x)$	consists of the limits on the control variables and the operating limits

The physical limits on the control variables cannot be violated. For example, source generation cannot exceed the MW limit of the machine. A solution in which these limits are violated would be meaningless because it would not be physically realizable. In contrast, operating limits (such as the voltage band criteria) are imposed to enhance security and do not represent physical bounds. They can be relaxed temporarily, if necessary, to obtain a feasible solution.

The maximization of Dynamic Transfer limits:

Objective

Max $\sum Abs(DT_i)$

i = 1 to n paths

Subject to

$\Delta V_k \leq 5$ KV for 500 KV and 345 KV buses

k = 1 , m buses (all the 500 KV and 345 KV buses)

$\Delta V_l \leq 2$ KV for 230 KV and 115 KV buses

i = 1 , p buses (all the 230 KV and 115 KV buses)

Where

DT_i = Path i Dynamic Transaction Value

ΔV_k = Bus voltage change at bus k due to dynamic transfers

The above problem can be solved using linear programming, quadratic programming, Newton's method, or other maximization solution techniques. In this study the linear programming technique is used. The objective function and constraints are linearized at the current operating point.

The change in bus voltage (ΔV) at any bus can be written as follows

$$\begin{matrix} \Delta\partial \\ \Delta V \end{matrix} = [J]-1 \begin{matrix} \Delta P \\ \Delta Q \end{matrix}$$

Dynamic transfers can be modeled as change in injection at each bus. The change in injection due to Dynamic Transfer is ΔI. Then the voltage changes at each bus can be obtained as follows

$$\begin{matrix} \Delta\partial \\ \Delta V \end{matrix} = [J]-1 \begin{matrix} \Delta I \\ 0 \end{matrix}$$

Voltage constraints can be introduced in Linear Programming to force the bus voltages to remain within the specified limits.

Transfer flows are a function of the voltages and angles at its terminal buses. Dynamic Transfer flow can be calculated as follows:

$$\Delta T_{km} = [\partial P_{km}/\partial V_k]\Delta V_k + [\partial P_{km}/\partial V_m]\Delta V_m + [\partial P_{km}/\partial ø_k]\Delta ø_k + [\partial P_{km}/\partial ø_m]\Delta ø_m$$

Where the Voltages and angle change with respect to transfer are as follows:

$$\begin{matrix} \Delta ø \\ \Delta V \end{matrix} = [J]-1 \begin{matrix} \Delta I \\ 0 \end{matrix}$$

Where

ΔT_{km}	= Change in flow due to voltage and angle change from bus k and bus m
$\partial P_{km}/\partial V_k$	= Partial derivate of MW flow from bus k to m with respect to voltage at bus k
$\partial P_{km}/\partial V_m$	= Partial derivate of MW flow from bus k to m with respect to voltage at bus m
ΔV_k	= Change in bus voltage at bus k
ΔV_m	= Change in bus voltage at bus m
$\partial P_{km}/\partial ø_k$	= Partial derivate of MW flow from bus k to m with respect to bus angle k
$\partial P_{km}/\partial ø_m$	= Partial derivate of MW flow from bus k to m with respect to bus angle k
$\Delta ø_k$	= Change in bus angle at bus k
$\Delta ø_m$	= Change in bus angle at bus m
J	= Jacobin matrix

4.0 Analysis

4.1 Case Description

Cases were built to represent a range of flow across each of the interties. The figures below are taken from the BPA 2008 Line Loadings Encyclopedia, and are representative of operational characteristics in typical recent years.

BC-US Intertie operation during winter months can be in either direction (figure 7). Cases were built representing operation over the range and are also varied with the extreme high and low Puget Sound area generation. As can be seen in figures 8 and 9, Puget Sound area generation can also operate at either high or low levels during the winter months. These variations were done to see how the local generation affected voltage support for that path.

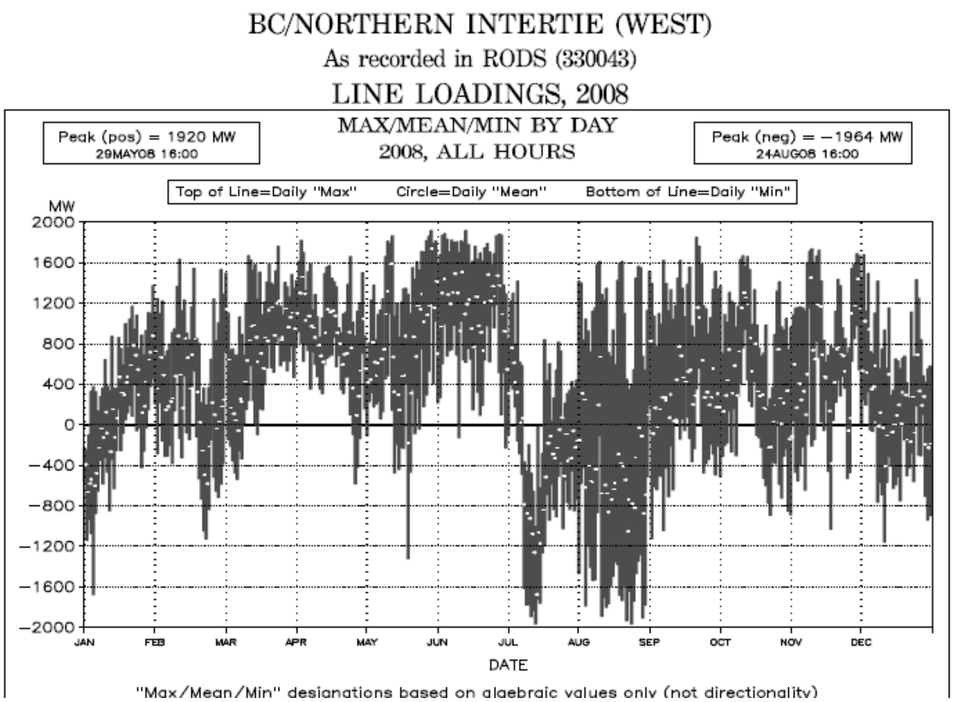

Figure 7: BC-US West (Custer-Ingledow) Path Historical Loading 2008 Line Loading Encyclopedia

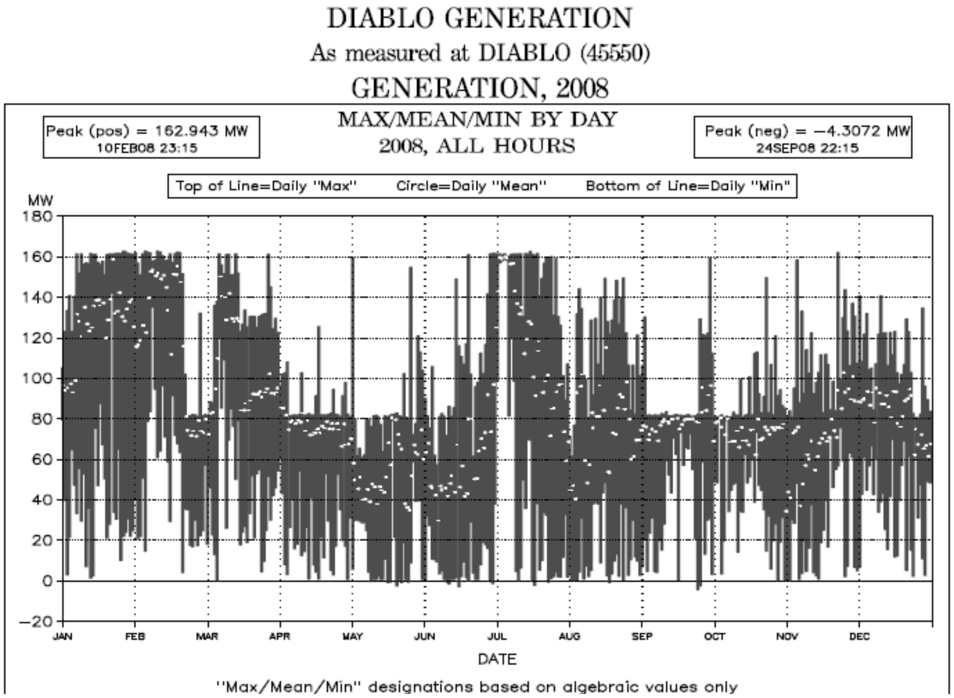

Figure 8: SCL Diablo Historical Generation
2008 Line Loading Encyclopedia

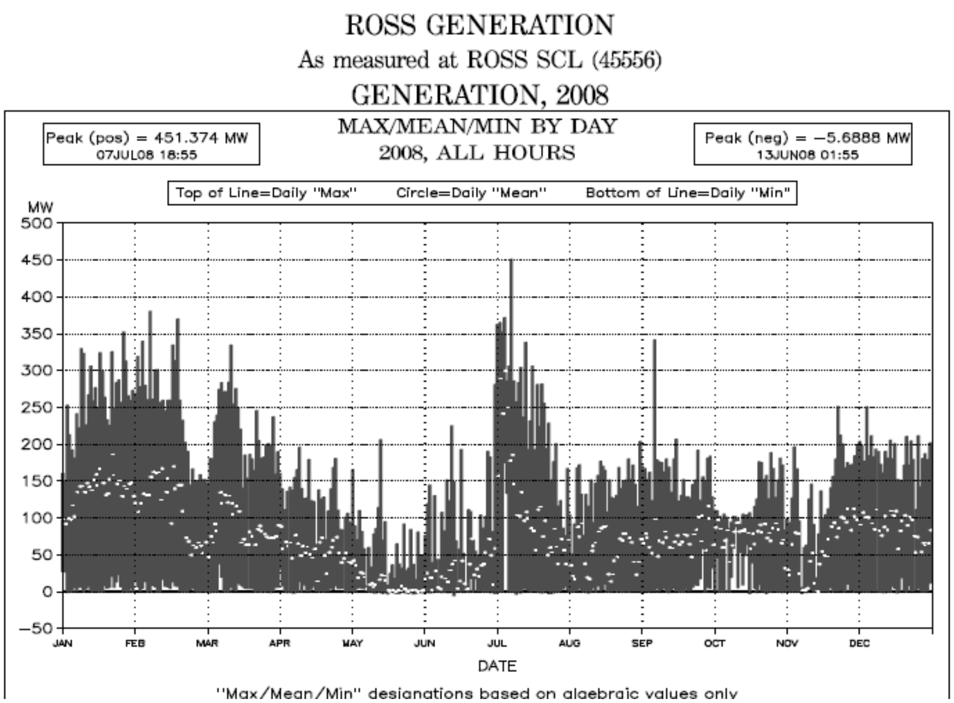

Figure 9: SCL Ross Historical Generation
2008 Line Loading Encyclopedia

COI operation is predominately southbound (figure 10). Dynamic transfer for COI was analyzed using COI 2009 and 2010 N-S nomogram cases (2009 HS, 2010 HW, 2010 LW).

Additional cases were built to represent southbound flows within the nomogram and were ramped keeping the COI and PDCI level proportional to their respective capabilities.

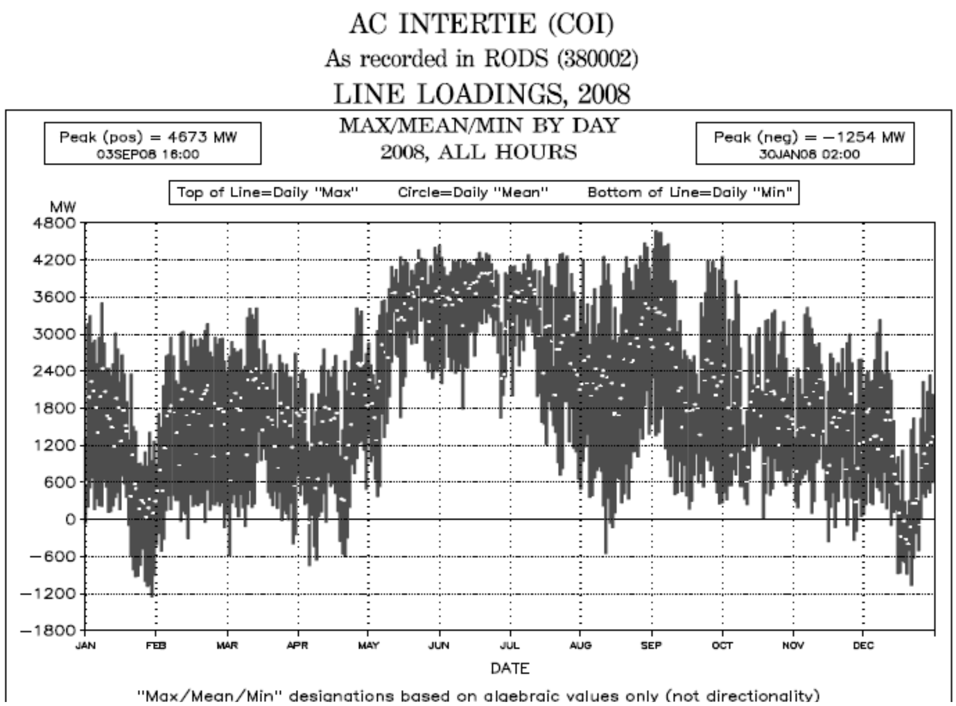

Figure 10: California-Oregon Intertie (COI) Path Historical Loading 2008 Line Loading Encyclopedia

West of Garrison flows are typically westbound (figure 11) and tend to be highest during light load hours with Colstrip at full output. The 2010 HLH and 2010 LLH COI nomogram cases represented a range of transfers from 900 to 2000 MW across West of Garrison. These cases were used to assess a range of high levels of flow on dynamic transfers.

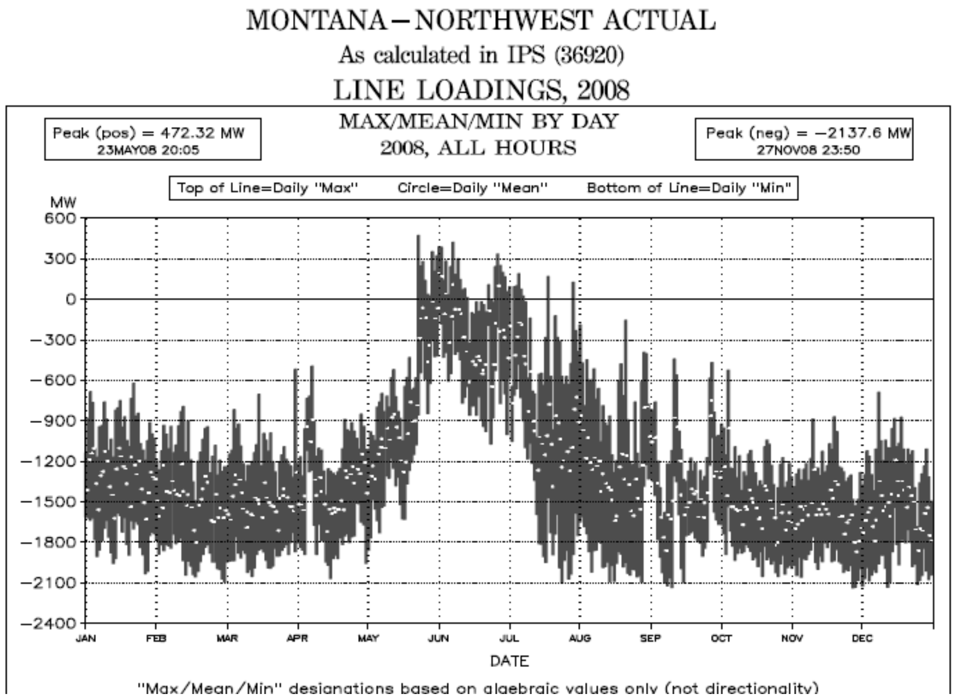

Figure 11: Montana-Northwest (West of Garrison) Path Historical Loading 2008 Line Loading Encyclopedia

The Idaho-PNW path is also typically westbound during the winter months (in the Idaho-NW figure 12 below, positive represents westbound flows, while in the Midpoint-Summer Lake figure 13, negative represents westbound). The 2010 HLH and 2010 LLH COI nomogram cases were built representing a range of transfer levels in the westbound direction from 0 MW to 700 MW. These cases were used to assess the relationship between dynamic transfer and the Idaho-PNW path loading.

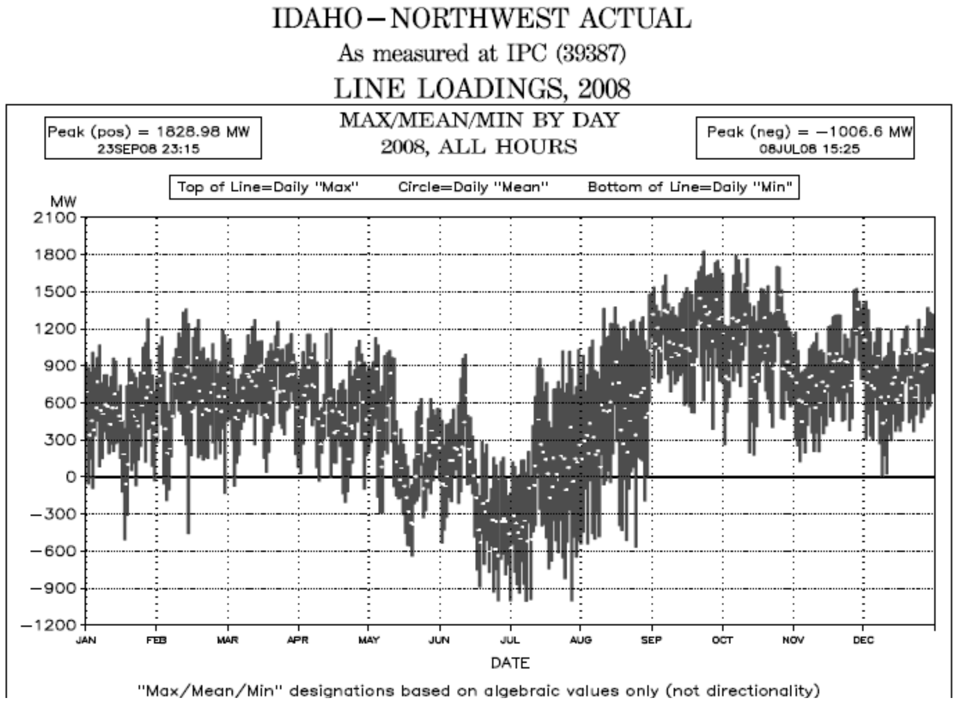

Figure 12: Idaho-Northwest Path Historical Loading
(positive is westbound)
2008 Line Loading Encyclopedia

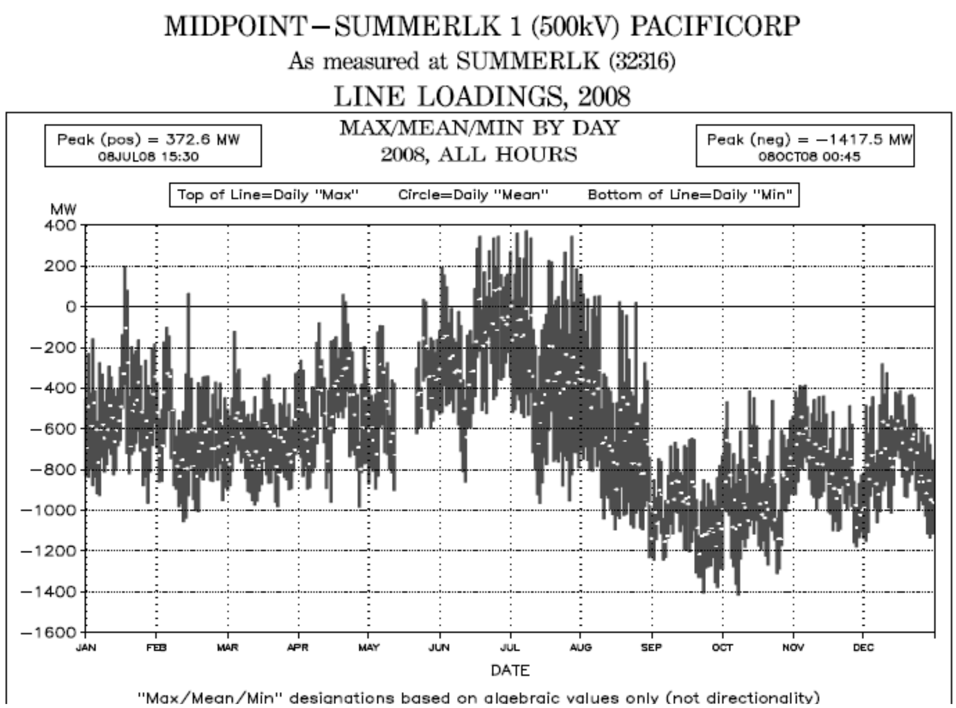

Figure 13: Midpoint-Summer Lake 500kV Line Historical Loading
(negative is westbound)
2008 Line Loading Encyclopedia

4.2 BC-US Intertie

Four transfer levels were run, two import and two export. In each pair, one of the cases was at the maximum level and the other at a lesser value to represent operation both at the system operating limit and nearer to the normal operating range. In addition, two of the Puget Sound generation patterns used for SOL studies were run, the 'g0' pattern representing minimum SCL, PSE, and SnoPUD generation, and the 'g11' pattern representing maximum SCL, PSE, and SnoPUD generation.

The System Operating Limits for the BC-US tie are

- 3150 MW N>S (2850 MW N>S on Ingledow-Custer)
- 2000 MW S>N (2000 MW S>N on Ingledow-Custer)

The Boundary-Nelway line (phase shifted), is limited to 400 MW in each direction, subject to generation at Boundary. In these study cases, the Boundary-Nelway flow was maintained at less than 200 MW.

To modify the flow across the intertie, hydro generation in BCTC, and FCRPS generation was used. For the G0 and G11 variations, generation on the LC was offset.

For N>S flow, transfers above 2000 MW require one or more Burrard (BGS) units to be in-service, per BCTC SO 7T-18. In 2850 N-S case, four BGS units were on at less than 50 MW per BCTC SO. At the intermediate levels and high S-N case, BGS units were off as not needed per BCTC SO. In all cases, voltages at MDN 230 and ING 230 were kept within appropriate AutoVAR scheme ranges (see figure 14). These schemes were locked with all other devices since the allowed voltage deviation at Custer 500 (5kV) was assumed to result in voltage deviations at MDN and ING 230 less than the Vhi and Vlo thresholds for switching.

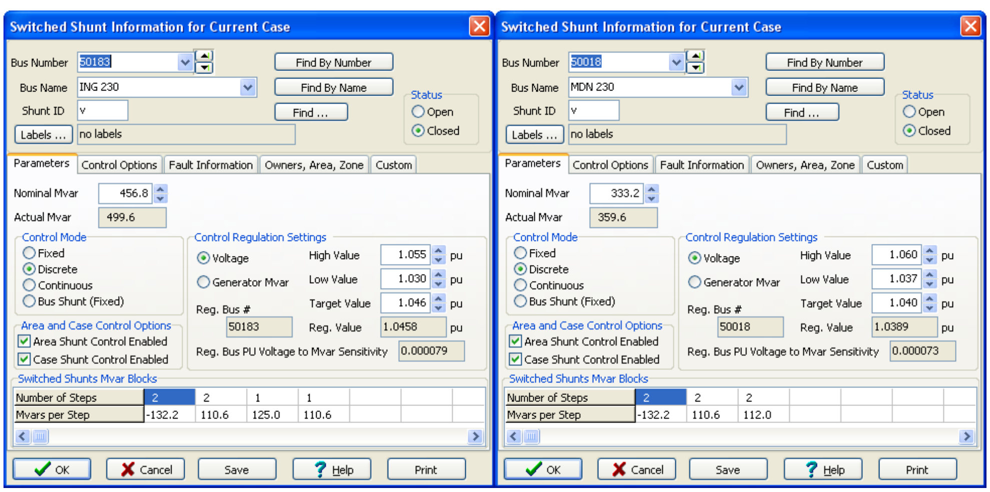

Figure 14: Ingledow 230 and Meridian 230 AutoVar scheme settings

A total of eight cases were run to evaluate Dynamic Transfer on the BC-US intertie. Tables 2 and 3 provide information on the cases.

Interface	N-2850_G0	N-2850_G11	N-1500_G0	N-1500_G11
COI	4149	4153	4179	4147
NORTHWEST - CANADA	-2937	-2937	-1586	-1586
MONTANA - NORTHWEST	917	906	911	901
IDAHO-NW	21	31	9	23
NORTH OF HANFORD	2635	3265	2521	2965
NORTH OF JOHN DAY	6579	7146	6286	6924
SOUTH OF ALLSTON	2453	2736	2323	2583
WEST OF CASCADES - NORTH	5459	4275	6663	5423
WEST OF CASCADES - SOUTH	4127	3997	4203	4093
WEST OF MCNARY	2498	2455	2489	2497
WEST OF SLATT	3713	3786	3654	3778
PDCI	3101	3101	3101	3101
ALTURAS PROJECT	8	8	8	8
KLAMATH FALLS COGEN	484	484	484	484
MPSL	-375	-385	-366	-381
Ingledow-Custer	2857	2856	1506	1507
RAVER-PAUL	811	1009	716	898
PAUL-ALLSTON	1791	2032	1681	1901
WSLD	12691	11336	12611	11245
NW-WA import	6561	5068	6555	5033
Olympic peninsula import	1185	1185	1185	1185
BCTC Area Load	7867	7867	7867	7867
NW Area Load	26027	26027	26027	26027
Puget Load	5781	5781	5781	5781

Area 40	N-2850_G0	N-2850_G11	N-1500_G0	N-1500_G11
Gen MW	30540	30610	31949	31934
Gen Mvar	1604	2315	2924	2866
Load MW	26028	26028	26028	26028
Load Mvar	6402	6402	6402	6402
Loss MW	1133	1198	1143	1164
Loss Mvar	522	962	760	639
Shunt Mvar (switched)	8327	8061	7316	7292

	N-2850_G0	N-2850_G11	N-1500_G0	N-1500_G11
Upper Columbia				
Gen MW	6050.4	5724.4	7199.2	6498.7
% Loading	77%	73%	83%	72%
Gen MVAr	-46.5	-121.9	389.6	27.5
Mid Columbia				
Gen MW	4265.2	4264.9	4264.9	4264.9
% Loading	86%	88%	88%	88%
Gen MVAr	674.8	757.9	813.9	792.2
Lower Columbia				
Gen MW	3739.9	3000	4149.4	3299.7
% Loading	73%	74%	77%	71%
Gen MVAr	-68.7	354.2	478.7	544.6
Lower Snake				
Gen MW	1849.6	1450.5	1700.3	1700.3
% Loading	70%	74%	67%	67%
Gen MVAr	-232.8	-242.1	-118.9	-68.2

Table 2: BC-US South to North Case Information

Interface	N500_G0	N500_G11	N2000_G0	N2000_G11
COI	4149	4138	4178	4161
NORTHWEST - CANADA	428	427	2009	2008
MONTANA - NORTHWEST	907	890	924	912
IDAHO-NW	11	18	4	12
NORTH OF HANFORD	1601	2121	1294	1930
NORTH OF JOHN DAY	6249	6991	5722	6345
SOUTH OF ALLSTON	2014	2303	1779	2086
WEST OF CASCADES - NORTH	8391	7146	9730	8478
WEST OF CASCADES - SOUTH	4489	4381	4656	4433
WEST OF MCNARY	2744	2757	2700	2691
WEST OF SLATT	3856	4006	3722	3844
PDCI	3101	3101	3101	3101
ALTURAS PROJECT	8	8	8	7
KLAMATH FALLS COGEN	484	484	484	484
MPSL	-389	-401	-376	-385
Ingledow-Custer	-508	-507	-2002	-2009
RAVER-PAUL	500	701	334	544
PAUL-ALLSTON	1417	1663	1216	1479
WSLD	12659	11274	12693	11186
NW-WA import	6607	5047	6705	5114
Olympic peninsula import	1185	1185	1185	1186
BCTC Area Load	8860	8860	8860	8860
NW Area Load	26027	26027	26027	26027
Puget Load	5781	5781	5781	5781
Area 40				
Gen MW	34010	33993	35692	35618
Gen Mvar	3152	3223	3674	3778
Load MW	26028	26028	26028	26028
Load Mvar	6402	6402	6402	6402
Loss MW	1213	1198	1299	1240
Loss Mvar	2123	1570	3852	2634
Shunt Mvar (switched)	8228	7698	8932	7900

		N500_G0	N500_G11	N2000_G0	N2000_G11
Upper Columbia					
	Gen MW	7199.2	6599.2	8400.9	7999.5
	% Loading	83%	73%	89%	89%
	Gen MVAr	688.4	305.4	1406.9	956.8
Mid Columbia					
	Gen MW	4615.3	4615.3	4615.3	4615.3
	% Loading	93%	93%	93%	93%
	Gen MVAr	871.1	848.3	929.2	931.6
Lower Columbia					
	Gen MW	4151	3199.2	4847.8	4049.2
	% Loading	74%	73%	86%	75%
	Gen MVAr	415.7	536.5	519.9	555.8
Lower Snake					
	Gen MW	3409.4	3409.4	3409.4	3000.3
	% Loading	87%	87%	87%	92%
	Gen MVAr	-1.1	67	-40.8	-0.7

Table 3: BC-US North to South Case Information

Tables 4 through 7 show the voltage changes at monitored buses within BPA. In all cases the voltage change was limited to 1.0%.

Sink injection groups were constrained to the range 100:500. The exception was the BCTC injection group which was constrained to the range 100:750 MW.

		N-2850_G0			N-2850_G11		
		Volt (kV)	% Change	kV Change	Volt (kV)	% Change	kV Change
40045 ALLSTON	500	536.0	0.19%	1.0	535.3	0.26%	1.4
40323 CUSTER W	500	517.8	0.84%	4.3	516.7	0.99%	5.1
40381 ECHOLAKE	500	541.9	0.14%	0.8	540.2	0.28%	1.5
40459 GARRISON	500	539.7	1.00%	5.4	539.8	1.00%	5.4
40489 GRIZZLY	500	547.5	0.88%	4.8	548.1	0.87%	4.8
40687 MALIN	500	542.6	0.98%	5.3	543.1	0.98%	5.3
40699 MARION	500	543.4	0.35%	1.9	547.0	0.26%	1.4
45197 MERIDINP	500	543.2	0.77%	4.2	545.0	0.74%	4.0
40749 MONROE	500	540.9	0.40%	2.2	537.9	0.58%	3.1
40797 OLYMPIA	500	536.1	0.02%	0.1	536.0	0.03%	0.1
40821 PAUL	500	540.0	0.01%	0.1	540.0	0.01%	0.1
40827 PEARL	500	542.5	0.01%	0.1	543.1	0.12%	0.7
40869 RAVER	500	543.0	0.07%	0.4	541.9	0.18%	1.0
40957 SCHULTZ	500	545.7	0.09%	0.5	545.1	0.20%	1.1
41007 SNOKING	500	540.2	0.33%	1.8	537.4	0.49%	2.6
41043 SUMMER L	500	546.0	0.80%	4.4	546.5	0.79%	4.3
41051 TACOMA	500	541.9	0.07%	0.4	540.7	0.18%	1.0
41057 TAFT	500	540.2	0.76%	4.1	540.5	0.79%	4.3
41138 WAUTOMA	500	544.2	0.26%	1.4	542.6	0.47%	2.5
40059 ASHE	230	236.8	0.10%	0.2	236.5	0.13%	0.3
40095 BELLNGHM	230	236.6	0.81%	1.9	237.4	0.54%	1.3
40099 BENTON	230	239.4	0.11%	0.3	239.0	0.14%	0.3
40321 CUSTER W	230	238.3	0.85%	2.0	238.5	0.85%	2.0
40621 LAGRANDE	230	239.4	0.62%	1.5	239.6	0.60%	1.4
43313 MCLOUGLN	230	239.5	0.02%	0.0	239.8	0.08%	0.2
48255 N LEWIST	230	239.2	0.24%	0.6	239.1	0.30%	0.7
45249 PONDROSA	230	239.5	0.78%	1.9	239.8	0.77%	1.9
40851 POTHOLES	230	238.9	0.12%	0.3	238.6	0.15%	0.4
40875 RDMND_E	230	240.0	0.72%	1.7	240.5	0.70%	1.7
40883 RESTON	230	233.4	0.61%	1.4	234.7	0.55%	1.3
43459 RIVRGATE	230	236.2	0.09%	0.2	236.2	0.17%	0.4
40905 ROUNDUP	230	238.3	0.53%	1.3	238.5	0.51%	1.2
40939 SANTIAM	230	236.8	0.36%	0.9	238.7	0.28%	0.7
41328 SNOH S2	230	235.8	0.30%	0.7	234.5	0.37%	0.9
43541 ST MARYS	230	236.8	0.10%	0.2	236.8	0.20%	0.5
48023 BEACON N	115	115.6	0.29%	0.3	115.7	0.32%	0.4
46401 BOTHELL	115	118.3	0.27%	0.3	117.4	0.37%	0.4
46409 BROAD ST	115	116.1	0.22%	0.3	115.1	0.34%	0.4
45037 CAVE JCT	115	118.8	0.89%	1.1	118.5	0.83%	1.0
40205 CHEHALIS	115	117.5	0.07%	0.1	117.3	0.12%	0.1
46425 EASTPINE	115	116.2	0.22%	0.3	115.3	0.33%	0.4
40387 ELLENSBG	115	115.7	0.07%	0.1	115.6	0.11%	0.1
45121 GRANT PS	115	120.3	0.80%	1.0	120.0	0.75%	0.9
40633 LAPINE	115	117.9	0.89%	1.1	118.1	0.88%	1.0
46433 MASS	115	116.3	0.21%	0.2	115.3	0.33%	0.4
40765 MURRAY	115	115.5	0.39%	0.5	115.0	0.41%	0.5
40775 NASELLE	115	118.1	0.18%	0.2	117.8	0.25%	0.3
45255 PRINVILE	115	116.2	0.75%	0.9	116.1	0.74%	0.9
40897 ROSS	115	119.7	0.04%	0.0	119.7	0.09%	0.1
40921 SALEM	115	118.3	0.28%	0.3	118.7	0.17%	0.2
46087 SANDUNES	115	117.7	0.08%	0.1	117.5	0.11%	0.1
48383 SHAWNEE	115	115.9	0.30%	0.3	115.8	0.36%	0.4
42502 TALBOT	115	116.8	0.14%	0.2	116.3	0.24%	0.3
46449 UNION	115	116.2	0.21%	0.2	115.3	0.33%	0.4
46453 UNIVERSY	115	116.1	0.24%	0.3	115.1	0.35%	0.4
46455 VIEWLAND	115	116.0	0.25%	0.3	114.9	0.36%	0.4
41147 WHITE BL	115	118.1	0.09%	0.1	118.0	0.12%	0.1
42701 WHITE RV	115	117.0	0.09%	0.1	116.1	0.18%	0.2

Table 4: BC-US N-S 2850 MW, Voltage Change resulting from Dynamic Transfer

			N-1500_G0			N-1500_G11		
			Volt (kV)	% Change	kV Change	Volt (kV)	% Change	kV Change
40045	ALLSTON	500	535.8	0.20%	1.1	534.8	0.26%	1.4
40323	CUSTER W	500	524.9	0.87%	4.6	526.6	1.03%	5.4
40381	ECHOLAKE	500	541.5	0.08%	0.5	542.9	0.22%	1.2
40459	GARRISON	500	539.2	1.00%	5.4	539.3	1.00%	5.4
40489	GRIZZLY	500	542.3	0.88%	4.8	542.5	0.87%	4.7
40687	MALIN	500	538.7	0.98%	5.3	539.1	0.98%	5.3
40699	MARION	500	545.8	0.31%	1.7	544.9	0.25%	1.4
45197	MERIDINP	500	543.4	0.75%	4.1	543.0	0.73%	4.0
40749	MONROE	500	544.1	0.33%	1.8	545.4	0.51%	2.8
40797	OLYMPIA	500	536.0	0.02%	0.1	536.1	0.03%	0.1
40821	PAUL	500	540.0	0.01%	0.1	540.0	0.02%	0.1
40827	PEARL	500	542.1	0.04%	0.2	540.8	0.13%	0.7
40869	RAVER	500	542.0	0.03%	0.1	543.3	0.14%	0.8
40957	SCHULTZ	500	543.6	0.08%	0.4	544.6	0.18%	1.0
41007	SNOKING	500	542.6	0.26%	1.4	543.7	0.43%	2.3
41043	SUMMER L	500	539.8	0.80%	4.3	540.1	0.79%	4.3
41051	TACOMA	500	541.0	0.02%	0.1	542.3	0.14%	0.7
41057	TAFT	500	539.5	0.79%	4.3	539.7	0.80%	4.3
41138	WAUTOMA	500	540.5	0.38%	2.1	539.2	0.51%	2.7
40059	ASHE	230	236.8	0.12%	0.3	236.6	0.15%	0.3
40095	BELLNGHM	230	235.7	0.79%	1.9	237.1	0.52%	1.2
40099	BENTON	230	239.3	0.13%	0.3	239.1	0.16%	0.4
40321	CUSTER W	230	236.5	0.85%	2.0	237.6	0.85%	2.0
40621	LAGRANDE	230	239.3	0.64%	1.5	239.4	0.63%	1.5
43313	MCLOUGLN	230	239.4	0.01%	0.0	239.0	0.08%	0.2
48255	N LEWIST	230	238.9	0.32%	0.8	239.2	0.35%	0.8
45249	PONDROSA	230	239.7	0.79%	1.9	239.9	0.78%	1.9
40851	POTHOLES	230	238.5	0.15%	0.4	238.6	0.17%	0.4
40875	RDMND_E	230	239.5	0.72%	1.7	239.7	0.71%	1.7
40883	RESTON	230	234.4	0.58%	1.4	233.9	0.54%	1.3
43459	RIVRGATE	230	237.3	0.10%	0.2	237.0	0.17%	0.4
40905	ROUNDUP	230	238.2	0.54%	1.3	238.4	0.53%	1.3
40939	SANTIAM	230	238.3	0.34%	0.8	238.0	0.29%	0.7
41328	SNOH S2	230	236.6	0.22%	0.5	236.7	0.31%	0.7
43541	ST MARYS	230	237.6	0.12%	0.3	237.0	0.21%	0.5
48023	BEACON N	115	115.6	0.34%	0.4	115.7	0.36%	0.4
46401	BOTHELL	115	118.6	0.20%	0.2	118.5	0.31%	0.4
46409	BROAD ST	115	116.3	0.16%	0.2	116.1	0.29%	0.3
45037	CAVE JCT	115	118.8	0.85%	1.0	118.6	0.82%	1.0
40205	CHEHALIS	115	117.4	0.07%	0.1	117.4	0.12%	0.1
46425	EASTPINE	115	116.4	0.16%	0.2	116.3	0.29%	0.3
40387	ELLENSBG	115	115.6	0.09%	0.1	115.5	0.12%	0.1
45121	GRANT PS	115	120.2	0.77%	0.9	120.1	0.74%	0.9
40633	LAPINE	115	117.7	0.90%	1.1	119.4	0.90%	1.1
46433	MASS	115	116.5	0.16%	0.2	116.3	0.29%	0.3
40765	MURRAY	115	115.9	0.31%	0.4	114.9	0.34%	0.4
40775	NASELLE	115	118.1	0.20%	0.2	117.9	0.27%	0.3
45255	PRINVILE	115	116.2	0.76%	0.9	116.3	0.74%	0.9
40897	ROSS	115	119.2	0.05%	0.1	119.1	0.09%	0.1
40921	SALEM	115	118.7	0.26%	0.3	118.5	0.19%	0.2
46087	SANDUNES	115	117.6	0.10%	0.1	117.5	0.13%	0.2
48383	SHAWNEE	115	115.7	0.40%	0.5	116.4	0.44%	0.5
42502	TALBOT	115	116.7	0.08%	0.1	116.8	0.20%	0.2
46449	UNION	115	116.4	0.16%	0.2	116.3	0.29%	0.3
46453	UNIVERSY	115	116.4	0.18%	0.2	116.2	0.31%	0.4
46455	VIEWLAND	115	116.3	0.19%	0.2	116.1	0.32%	0.4
41147	WHITE BL	115	118.1	0.11%	0.1	118.0	0.14%	0.2
42701	WHITE RV	115	116.4	0.05%	0.1	116.5	0.15%	0.2

Table 5: BC-US N-S 1500 MW, Voltage Change resulting from Dynamic Transfer

			N500_G0			N500_G11		
			Volt (kV)	% Change	kV Change	Volt (kV)	% Change	kV Change
40045	ALLSTON	500	536.2	0.22%	1.2	535.3	0.22%	1.2
40323	CUSTER W	500	527.9	0.14%	0.7	531.0	0.30%	1.6
40381	ECHOLAKE	500	539.0	0.70%	3.8	540.0	0.23%	1.3
40459	GARRISON	500	539.8	0.55%	3.0	539.8	0.55%	3.0
40489	GRIZZLY	500	543.2	0.86%	4.7	543.2	0.87%	4.7
40687	MALIN	500	539.8	0.99%	5.4	539.8	0.98%	5.3
40699	MARION	500	546.9	0.30%	1.6	546.0	0.32%	1.7
45197	MERIDINP	500	547.2	0.70%	3.9	546.8	0.75%	4.1
40749	MONROE	500	540.4	0.76%	4.1	539.4	0.18%	1.0
40797	OLYMPIA	500	535.9	0.01%	0.1	536.0	0.01%	0.0
40821	PAUL	500	540.0	0.01%	0.0	540.0	0.01%	0.1
40827	PEARL	500	540.7	0.04%	0.2	539.5	0.05%	0.3
40869	RAVER	500	540.1	0.63%	3.4	540.1	0.23%	1.2
40957	SCHULTZ	500	542.2	0.35%	1.9	543.0	0.08%	0.4
41007	SNOKING	500	539.2	0.76%	4.1	539.1	0.19%	1.0
41043	SUMMER L	500	540.6	0.91%	4.9	540.7	0.79%	4.3
41051	TACOMA	500	539.6	0.64%	3.5	536.7	0.23%	1.2
41057	TAFT	500	540.3	0.44%	2.4	540.4	0.47%	2.5
41138	WAUTOMA	500	543.5	0.27%	1.4	542.1	0.37%	2.0
40059	ASHE	230	237.2	0.10%	0.2	237.0	0.11%	0.2
40095	BELLNGHM	230	236.2	0.17%	0.4	237.8	0.09%	0.2
40099	BENTON	230	239.9	0.10%	0.2	239.7	0.11%	0.3
40321	CUSTER W	230	237.6	0.03%	0.1	237.1	0.21%	0.5
40621	LAGRANDE	230	239.1	0.37%	0.9	239.3	0.64%	1.5
43313	MCLOUGLN	230	238.7	0.00%	0.0	238.3	0.01%	0.0
48255	N LEWIST	230	239.4	0.26%	0.6	239.2	0.17%	0.4
45249	PONDROSA	230	240.1	0.82%	2.0	240.1	0.78%	1.9
40851	POTHOLES	230	239.1	0.14%	0.3	239.1	0.13%	0.3
40875	RDMND_E	230	239.9	0.70%	1.7	239.9	0.70%	1.7
40883	RESTON	230	235.7	0.54%	1.3	235.5	0.58%	1.4
43459	RIVRGATE	230	237.5	0.10%	0.2	237.1	0.11%	0.3
40905	ROUNDUP	230	238.1	0.31%	0.7	238.2	0.54%	1.3
40939	SANTIAM	230	238.6	0.34%	0.8	238.3	0.35%	0.8
41328	SNOH S2	230	234.1	0.77%	1.8	235.1	0.19%	0.4
43541	ST MARYS	230	237.6	0.13%	0.3	237.0	0.14%	0.3
48023	BEACON N	115	115.4	0.29%	0.3	115.5	0.27%	0.3
46401	BOTHELL	115	117.8	0.75%	0.9	117.9	0.19%	0.2
46409	BROAD ST	115	115.9	0.74%	0.9	115.8	0.19%	0.2
45037	CAVE JCT	115	119.0	0.79%	0.9	118.8	0.85%	1.0
40205	CHEHALIS	115	117.5	0.01%	0.0	117.4	0.04%	0.0
46425	EASTPINE	115	116.1	0.73%	0.9	116.0	0.19%	0.2
40387	ELLENSBG	115	115.6	0.04%	0.0	115.5	0.07%	0.1
45121	GRANT PS	115	120.0	0.71%	0.9	119.9	0.77%	0.9
40633	LAPINE	115	117.9	0.89%	1.1	118.0	0.89%	1.0
46433	MASS	115	116.1	0.73%	0.8	116.0	0.19%	0.2
40765	MURRAY	115	114.9	0.79%	0.9	114.6	0.16%	0.2
40775	NASELLE	115	118.3	0.21%	0.2	118.1	0.21%	0.2
45255	PRINVILE	115	116.4	0.77%	0.9	116.4	0.74%	0.9
40897	ROSS	115	119.2	0.04%	0.0	119.1	0.05%	0.1
40921	SALEM	115	118.7	0.25%	0.3	118.5	0.26%	0.3
46087	SANDUNES	115	117.6	0.07%	0.1	117.6	0.08%	0.1
48383	SHAWNEE	115	115.6	0.30%	0.3	115.5	0.22%	0.3
42502	TALBOT	115	116.6	0.69%	0.8	116.9	0.22%	0.3
46449	UNION	115	116.1	0.73%	0.8	116.0	0.19%	0.2
46453	UNIVERSY	115	115.9	0.74%	0.9	115.8	0.19%	0.2
46455	VIEWLAND	115	115.7	0.74%	0.9	115.6	0.18%	0.2
41147	WHITE BL	115	118.2	0.06%	0.1	118.1	0.08%	0.1
42701	WHITE RV	115	116.4	0.60%	0.7	116.9	0.20%	0.2

Table 6: BC-US S-N 500 MW, Voltage Change resulting from Dynamic Transfer

		N2000_G0			N2000_G11		
		Volt (kV)	% Change	kV Change	Volt (kV)	% Change	kV Change
40045 ALLSTON	500	535.4	0.09%	0.5	536.2	0.18%	1.0
40323 CUSTER W	500	520.4	0.61%	3.2	528.6	0.63%	3.3
40381 ECHOLAKE	500	533.0	0.62%	3.3	539.3	0.75%	4.1
40459 GARRISON	500	540.6	1.00%	5.4	540.5	0.55%	3.0
40489 GRIZZLY	500	543.0	0.89%	4.8	544.2	0.88%	4.8
40687 MALIN	500	539.7	0.98%	5.3	542.2	0.98%	5.3
40699 MARION	500	546.8	0.43%	2.4	544.3	0.36%	2.0
45197 MERIDINP	500	547.3	0.79%	4.3	542.5	0.75%	4.1
40749 MONROE	500	528.6	0.79%	4.2	537.0	1.00%	5.4
40797 OLYMPIA	500	535.8	0.01%	0.1	534.4	0.01%	0.1
40821 PAUL	500	540.0	0.01%	0.0	540.0	0.01%	0.0
40827 PEARL	500	540.1	0.13%	0.7	539.0	0.01%	0.1
40869 RAVER	500	534.9	0.54%	2.9	538.7	0.64%	3.5
40957 SCHULTZ	500	538.0	0.31%	1.7	540.7	0.35%	1.9
41007 SNOKING	500	527.5	0.75%	4.0	533.3	0.92%	4.9
41043 SUMMER L	500	540.5	0.80%	4.3	542.3	0.82%	4.5
41051 TACOMA	500	533.0	0.55%	2.9	535.8	0.65%	3.5
41057 TAFT	500	541.5	0.74%	4.0	541.4	0.45%	2.4
41138 WAUTOMA	500	543.2	0.09%	0.5	540.1	0.19%	1.0
40059 ASHE	230	237.3	0.05%	0.1	237.0	0.10%	0.2
40095 BELLNGHM	230	234.7	0.75%	1.8	238.0	0.45%	1.1
40099 BENTON	230	239.9	0.05%	0.1	239.7	0.10%	0.2
40321 CUSTER W	230	236.7	0.67%	1.6	238.2	0.59%	1.4
40621 LAGRANDE	230	239.0	0.67%	1.6	239.1	0.60%	1.4
43313 MCLOUGLN	230	238.9	0.14%	0.3	238.2	0.04%	0.1
48255 N LEWIST	230	239.8	0.20%	0.5	239.6	0.18%	0.4
45249 PONDROSA	230	240.0	0.80%	1.9	239.5	0.80%	1.9
40851 POTHOLES	230	239.1	0.09%	0.2	238.9	0.13%	0.3
40875 RDMND_E	230	239.7	0.73%	1.8	239.6	0.72%	1.7
40883 RESTON	230	235.8	0.65%	1.5	233.0	0.60%	1.4
43459 RIVRGATE	230	235.4	0.02%	0.0	236.1	0.07%	0.2
40905 ROUNDUP	230	238.0	0.56%	1.3	238.1	0.50%	1.2
40939 SANTIAM	230	238.6	0.43%	1.0	237.6	0.39%	0.9
41328 SNOH S2	230	234.6	0.74%	1.7	234.9	0.79%	1.9
43541 ST MARYS	230	235.8	0.04%	0.1	237.0	0.08%	0.2
48023 BEACON N	115	115.9	0.28%	0.3	115.9	0.23%	0.3
46401 BOTHELL	115	118.3	0.72%	0.9	118.2	0.79%	0.9
46409 BROAD ST	115	116.1	0.70%	0.8	115.9	0.76%	0.9
45037 CAVE JCT	115	118.0	0.91%	1.1	118.5	0.87%	1.0
40205 CHEHALIS	115	117.4	0.07%	0.1	117.1	0.05%	0.1
46425 EASTPINE	115	116.3	0.70%	0.8	116.1	0.76%	0.9
40387 ELLENSBG	115	115.5	0.02%	0.0	115.5	0.04%	0.0
45121 GRANT PS	115	119.6	0.82%	1.0	120.0	0.78%	0.9
40633 LAPINE	115	117.9	0.91%	1.1	117.7	0.90%	1.1
46433 MASS	115	116.4	0.70%	0.8	116.1	0.76%	0.9
40765 MURRAY	115	114.6	0.81%	0.9	115.3	0.77%	0.9
40775 NASELLE	115	118.4	0.07%	0.1	118.2	0.15%	0.2
45255 PRINVILE	115	116.3	0.77%	0.9	116.2	0.76%	0.9
40897 ROSS	115	119.5	0.03%	0.0	119.6	0.02%	0.0
40921 SALEM	115	118.9	0.34%	0.4	118.4	0.30%	0.4
46087 SANDUNES	115	117.6	0.02%	0.0	117.6	0.07%	0.1
48383 SHAWNEE	115	115.8	0.25%	0.3	115.8	0.23%	0.3
42502 TALBOT	115	116.8	0.61%	0.7	116.7	0.70%	0.8
46449 UNION	115	116.3	0.70%	0.8	116.1	0.76%	0.9
46453 UNIVERSY	115	116.2	0.71%	0.8	116.0	0.77%	0.9
46455 VIEWLAND	115	116.1	0.72%	0.8	115.9	0.78%	0.9
41147 WHITE BL	115	118.2	0.03%	0.0	118.2	0.07%	0.1
42701 WHITE RV	115	116.7	0.52%	0.6	116.7	0.60%	0.7

Table 7: BC-US S-N 2000 MW, Voltage Change resulting from Dynamic Transfer

As noted by the calculated MW transfer variation (tables 8-9) below, the case is more sensitive to changes at both SOL extremes. The lowest transfer variations were found at high N-S flow, which is known to be voltage stability limited. At high S-N flow, the sensitivity itself was highly sensitive to Puget Sound generation levels, with the highest dynamic transfer variations with the local generation on to provide voltage support, and the lowest dynamic transfers when it was off and not providing voltage support. The N500_G0 case had inconsistently high dynamic transfer, and requires further examination to determine if it is correct or the result of an unidentified problem with the case.

For most of the range, the calculated dynamic transfer level centers around 300 MW. This value corresponds to the dynamic transfer limit currently in place for the BC-US tie and has been proven by several years experience.

North to South Cases	**Calculated Transfer Variation within Voltage Constraints**			
Interface Name	N-2850_G0	N-2850_G11	N-1500_G0	N-1500_G11
COI	378	395	362	380
NORTHWEST - CANADA	120	190	265	337
MONTANA - NORTHWEST	101	100	97	96
IDAHO-NW	320	321	322	323
NORTH OF HANFORD	393	432	473	514
NORTH OF JOHN DAY	272	327	384	441
SOUTH OF ALLSTON	378	390	408	422
WEST OF CASCADES - NORTH	422	471	526	579
WEST OF CASCADES - SOUTH	292	297	302	310
WEST OF MCNARY	154	164	173	183
WEST OF SLATT	135	136	125	126
Injection Group Location	MW	MW	MW	MW
NW Wind South of NJD (Columbia Gorge)	1622	1702	1739	1826
Northern California Hydro Generation	-303	-321	-284	-303
Westside Generation (Centralia)	-500	-500	-500	-500
BCTC Hydro	-120	-190	-265	-337
Idaho Generation (Bridger)	-500	-500	-500	-500
Montana Generation (Colstrip)	-198	-191	-190	-186

Table 8: Dynamic Transfer calculated from ∂V/∂P and 1% voltage constraint

South to North Cases	**Calculated Transfer Variation within Voltage Constraints**			
Interface Name	N500_G0	N500_G11	N2000_G0	N2000_G11
COI	449	386	351	386
NORTHWEST - CANADA	703	433	178	517
MONTANA - NORTHWEST	14	96	98	78
IDAHO-NW	85	324	320	277
NORTH OF HANFORD	656	537	428	578
NORTH OF JOHN DAY	635	512	316	560
SOUTH OF ALLSTON	453	401	395	419
WEST OF CASCADES - NORTH	824	610	468	675
WEST OF CASCADES - SOUTH	321	290	298	298
WEST OF MCNARY	184	189	162	192
WEST OF SLATT	98	121	126	112
Injection Group Location	MW	MW	MW	MW
NW Wind South of NJD (Columbia Gorge)	1856	1843	1657	1862
Northern California Hydro Generation	-453	-310	-274	-323
Westside Generation (Centralia)	-500	-500	-500	-500
BCTC Hydro	-703	-433	-178	-517
Idaho Generation (Bridger)	-100	-500	-500	-422
Montana Generation (Colstrip)	-100	-100	-205	-100

Table 9: Dynamic Transfer calculated from ∂V/∂P and 1% voltage constraint

4.3 COI

A total of eight cases were run, representing heavy load hour cases in summer and winter, and light load cases in winter. The cases evaluated were used to set the nomogram points for COI. As such they represent the voltage stability limited operating points.

The System Operating Limits for the COI are

- 4800 MW N-S, 3675 MW S-N

Tables 10 and 11 provide information on the cases

Interface	10 HW pt 1	10 HW pt 2	10 LW W12	10 LW W9
COI	4807	4477	-3675	-3860
NORTHWEST - CANADA	-1689	-1738	1056	1993
MONTANA - NORTHWEST	913	918	2038	2075
IDAHO-NW	-13	-1	784	756
NORTH OF HANFORD	3353	3552	-3358	-3806
NORTH OF JOHN DAY	7449	7708	-2584	-3360
SOUTH OF ALLSTON	2760	2816	-963	-951
WEST OF CASCADES - NORTH	6330	6339	6344	5164
WEST OF CASCADES - SOUTH	4123	4009	4416	3954
WEST OF MCNARY	2748	2664	417	432
WEST OF SLATT	4102	4095	-32	-164
PDCI	3101	2889	-1323	-2113
ALTURAS PROJECT	8	8	58	55
KLAMATH FALLS COGEN	484	484	484	0
MPSL	-409	-403	-491	-456
Ingledow-Custer	1609	1658	-976	-1913
RAVER-PAUL	963	1001	-438	-671
PAUL-ALLSTON	1986	2032	-75	-123
WSLD	12171	12170	12054	8957
NW-WA import	5950	5951	5716	3601
Olympic peninsula import	1185	1185	1017	707
Area 40	10 HW pt 1	10 HW pt 2	10 LW W12	10 LW W9
Gen MW	32640	32020	15455	13010
Gen Mvar	3539	3551	-1101	-1105
Load MW	26028	26028	21405	19055
Load Mvar	6402	6402	4881	4444
Loss MW	1284	1275	756	705
Loss Mvar	2859	2744	-5688	-6617
Shunt Mvar (switched)	8960	8664	3549	2265
	10 HW pt 1	10 HW pt 2	10 LW W12	10 LW W9
Upper Columbia				
Gen MW	8000	8300.4	1790.1	299.9
% Loading	93%	88%	87%	26%
Gen MVAr	597.9	664.1	-331.4	-631.4
Mid Columbia				
Gen MW	4264.9	4264.9	1839.7	1420.1
% Loading	88%	88%	80%	78%
Gen MVAr	872.8	891.9	65.6	46.7
Lower Columbia				
Gen MW	3409.9	2489.6	2310.2	1580.1
% Loading	83%	82%	80%	84%
Gen MVAr	494.6	395	-694.4	-286.8
Lower Snake				
Gen MW	1709.8	1709.8	430	430
% Loading	81%	81%	64%	64%
Gen MVAr	-34.4	15.3	-210.1	-161.3

Table 10: COI 2010 Winter HLH, LLH Case Information

Interface	09 HS pt 1	09 HS pt 2	09 HS pt 3	09 HS pt 4
COI	4801	4419	4222	4102
NORTHWEST - CANADA	-2301	-2299	-2300	-2300
MONTANA - NORTHWEST	1201	1183	926	944
IDAHO-NW	29	76	-1041	-1005
NORTH OF HANFORD	3974	3986	3854	4016
NORTH OF JOHN DAY	7218	7799	7278	7498
SOUTH OF ALLSTON	2673	2786	2878	2939
WEST OF CASCADES - NORTH	3599	3480	3826	3724
WEST OF CASCADES - SOUTH	3970	4022	3849	3841
WEST OF MCNARY	2111	2125	2173	1855
WEST OF SLATT	3503	3618	3617	3439
PDCI	3097	2856	2726	2651
ALTURAS PROJECT	1	3	2	1
KLAMATH FALLS COGEN	484	484	484	484
MPSL	-396	-400	399	397
Ingledow-Custer	2301	2299	2301	2301
RAVER-PAUL	1356	1432	1169	1205
PAUL-ALLSTON	2285	2376	2381	2430
WSLD	10006	10010	10087	10010
NW-WA import	3333	3096	3356	3192
Olympic peninsula import	690	690	690	690

Area 40	09 HS pt 1	09 HS pt 2	09 HS pt 3	09 HS pt 4
Gen MW	29369	28464	30354	29939
Gen Mvar	2235	2068	2543	2471
Load MW	23782	23542	24342	24177
Load Mvar	6353	6314	6443	6417
Loss MW	1168	1153	1198	1195
Loss Mvar	446	349	992	933
Shunt Mvar (switched)	7690	7726	7458	7450

	09 HS pt 1	09 HS pt 2	09 HS pt 3	09 HS pt 4
Upper Columbia				
Gen MW	7250.4	7020.4	7410.4	7576.8
% Loading	88%	86%	88%	88%
Gen MVAr	289.7	255.7	366.5	416.3
Mid Columbia				
Gen MW	3611.4	3611.4	3611.4	3611.4
% Loading	85%	85%	85%	85%
Gen MVAr	775.6	790.5	801.5	832
Lower Columbia				
Gen MW	4514	3079.3	3859.4	3278.4
% Loading	83%	86%	84%	84%
Gen MVAr	386.4	174.7	348.6	52.6
Lower Snake				
Gen MW	390.3	1150	1210	1210
% Loading	59%	80%	76%	76%
Gen MVAr	-178.5	-86	-137.4	-50.3

Table 11: COI 2009 Summer HLH Case Information

Tables 12-15 show the voltage changes at monitored buses within BPA. In all cases the voltage change was limited to 1.0%.

Optimization constrained all sink injection groups to the range 100:500. The exception was the BCTC injection group which was constrained to the range 100:300 MW.

			10 HW pt 1			10 HW pt 2		
			Volt (kV)	% Change	kV Change	Volt (kV)	% Change	kV Change
40045	ALLSTON	500	534.5	0.32%	1.7	534.3	0.33%	1.8
40323	CUSTER W	500	526.7	0.95%	5.0	526.2	0.95%	5.0
40381	ECHOLAKE	500	546.7	0.20%	1.1	544.8	0.21%	1.1
40459	GARRISON	500	538.7	1.00%	5.4	538.5	1.00%	5.4
40489	GRIZZLY	500	540.8	0.86%	4.6	540.1	0.85%	4.6
40687	MALIN	500	535.2	0.99%	5.3	537.4	0.99%	5.3
40699	MARION	500	539.2	0.08%	0.4	539.9	0.08%	0.4
45197	MERIDINP	500	540.2	0.63%	3.4	542.1	0.64%	3.5
40749	MONROE	500	551.3	0.45%	2.5	549.4	0.45%	2.5
40797	OLYMPIA	500	535.9	0.03%	0.2	536.0	0.03%	0.2
40821	PAUL	500	540.0	0.02%	0.1	540.0	0.02%	0.1
40827	PEARL	500	538.5	0.28%	1.5	538.5	0.29%	1.6
40869	RAVER	500	546.4	0.13%	0.7	545.5	0.14%	0.8
40957	SCHULTZ	500	543.3	0.20%	1.1	542.2	0.21%	1.1
41007	SNOKING	500	547.3	0.37%	2.0	543.5	0.38%	2.0
41043	SUMMER L	500	538.5	0.78%	4.2	537.7	0.78%	4.2
41051	TACOMA	500	544.7	0.13%	0.7	544.2	0.14%	0.7
41057	TAFT	500	539.5	0.79%	4.3	539.2	0.80%	4.3
41138	WAUTOMA	500	540.0	0.62%	3.4	538.8	0.66%	3.5
40059	ASHE	230	236.6	0.16%	0.4	236.3	0.17%	0.4
40095	BELLNGHM	230	237.0	0.65%	1.5	237.0	0.65%	1.5
40099	BENTON	230	239.2	0.17%	0.4	239.0	0.17%	0.4
40321	CUSTER W	230	239.4	0.85%	2.0	239.2	0.85%	2.0
40621	LAGRANDE	230	238.2	0.44%	1.0	239.0	0.48%	1.2
43313	MCLOUGLN	230	238.7	0.21%	0.5	238.6	0.22%	0.5
48255	N LEWIST	230	238.6	0.31%	0.7	238.4	0.31%	0.7
45249	PONDROSA	230	240.0	0.78%	1.9	239.9	0.77%	1.8
40851	POTHOLES	230	237.7	0.22%	0.5	237.6	0.22%	0.5
40875	RDMND_E	230	239.2	0.70%	1.7	239.3	0.69%	1.6
40883	RESTON	230	232.9	0.39%	0.9	233.5	0.40%	0.9
43459	RIVRGATE	230	235.2	0.29%	0.7	235.2	0.30%	0.7
40905	ROUNDUP	230	237.2	0.32%	0.8	238.0	0.41%	1.0
40939	SANTIAM	230	237.0	0.07%	0.2	237.4	0.07%	0.2
41328	SNOH S2	230	237.1	0.27%	0.6	238.1	0.28%	0.7
43541	ST MARYS	230	236.0	0.35%	0.8	235.9	0.36%	0.8
48023	BEACON N	115	115.6	0.33%	0.4	115.6	0.33%	0.4
46401	BOTHELL	115	118.6	0.27%	0.3	119.3	0.28%	0.3
46409	BROAD ST	115	116.2	0.25%	0.3	116.9	0.26%	0.3
45037	CAVE JCT	115	119.2	0.70%	0.8	119.6	0.71%	0.8
40205	CHEHALIS	115	117.3	0.14%	0.2	117.3	0.15%	0.2
46425	EASTPINE	115	116.4	0.25%	0.3	117.0	0.26%	0.3
40387	ELLENSBG	115	115.5	0.16%	0.2	115.4	0.17%	0.2
45121	GRANT PS	115	119.6	0.63%	0.7	120.0	0.63%	0.8
40633	LAPINE	115	119.0	0.89%	1.1	119.2	0.88%	1.0
46433	MASS	115	116.4	0.25%	0.3	117.0	0.25%	0.3
40765	MURRAY	115	114.9	0.31%	0.4	115.3	0.32%	0.4
40775	NASELLE	115	117.8	0.32%	0.4	117.7	0.33%	0.4
45255	PRINVILE	115	116.2	0.74%	0.9	116.2	0.73%	0.8
40897	ROSS	115	119.2	0.19%	0.2	119.2	0.20%	0.2
40921	SALEM	115	118.5	0.01%	0.0	118.5	0.01%	0.0
46087	SANDUNES	115	117.3	0.17%	0.2	117.2	0.18%	0.2
48383	SHAWNEE	115	116.6	0.37%	0.4	116.5	0.38%	0.4
42502	TALBOT	115	116.5	0.18%	0.2	116.9	0.18%	0.2
46449	UNION	115	116.4	0.25%	0.3	117.0	0.26%	0.3
46453	UNIVERSY	115	116.3	0.27%	0.3	117.0	0.27%	0.3
46455	VIEWLAND	115	116.2	0.27%	0.3	116.9	0.28%	0.3
41147	WHITE BL	115	118.0	0.15%	0.2	117.9	0.16%	0.2
42701	WHITE RV	115	116.4	0.13%	0.2	116.6	0.14%	0.2

Table 12: COI 2010 Winter HLH Voltage Change resulting from Dynamic Transfer

		10 LW W12			10 LW W9		
		Volt (kV)	% Change	kV Change	Volt (kV)	% Change	kV Change
40045 ALLSTON	500	536.2	0.39%	2.1	540.0	0.11%	0.6
40323 CUSTER W	500	526.1	0.21%	1.1	523.7	0.14%	0.7
40381 ECHOLAKE	500	545.4	0.55%	3.0	546.6	0.20%	1.1
40459 GARRISON	500	546.0	0.92%	5.0	543.5	0.92%	5.0
40489 GRIZZLY	500	541.2	0.31%	1.7	538.9	0.28%	1.5
40687 MALIN	500	540.7	0.91%	4.9	539.2	0.88%	4.7
40699 MARION	500	542.3	0.26%	1.4	543.7	0.30%	1.7
45197 MERIDINP	500	538.8	0.77%	4.1	542.0	0.72%	3.9
40749 MONROE	500	541.0	0.53%	2.9	537.6	0.23%	1.2
40797 OLYMPIA	500	533.3	0.35%	1.9	537.7	0.50%	2.7
40821 PAUL	500	536.3	0.33%	1.8	540.5	0.52%	2.8
40827 PEARL	500	539.6	0.51%	2.8	543.0	0.47%	2.6
40869 RAVER	500	547.6	0.52%	2.9	549.7	0.15%	0.8
40957 SCHULTZ	500	546.8	0.43%	2.4	547.2	0.26%	1.4
41007 SNOKING	500	541.9	0.54%	2.9	539.7	0.22%	1.2
41043 SUMMER L	500	542.5	0.82%	4.4	541.2	0.77%	4.2
41051 TACOMA	500	546.9	0.53%	2.9	549.5	0.14%	0.8
41057 TAFT	500	546.6	0.64%	3.5	543.4	0.64%	3.5
41138 WAUTOMA	500	544.7	0.43%	2.3	544.4	0.42%	2.3
40059 ASHE	230	237.3	0.09%	0.2	237.0	0.10%	0.2
40095 BELLNGHM	230	239.1	0.20%	0.5	237.1	0.10%	0.2
40099 BENTON	230	244.0	0.09%	0.2	243.6	0.10%	0.2
40321 CUSTER W	230	237.7	0.22%	0.5	237.9	0.13%	0.3
40621 LAGRANDE	230	239.1	0.06%	0.1	239.2	0.04%	0.1
43313 MCLOUGLN	230	238.3	0.53%	1.3	239.4	0.53%	1.3
48255 N LEWIST	230	243.7	0.19%	0.5	243.2	0.18%	0.4
45249 PONDROSA	230	239.8	0.11%	0.3	240.0	0.09%	0.2
40851 POTHOLES	230	241.3	0.09%	0.2	240.9	0.10%	0.3
40875 RDMND_E	230	236.6	0.25%	0.6	238.5	0.21%	0.5
40883 RESTON	230	235.3	0.19%	0.5	236.0	0.14%	0.3
43459 RIVRGATE	230	235.9	0.37%	0.9	237.3	0.26%	0.6
40905 ROUNDUP	230	240.1	0.02%	0.1	240.1	0.01%	0.0
40939 SANTIAM	230	236.7	0.21%	0.5	236.7	0.25%	0.6
41328 SNOH S2	230	238.4	0.47%	1.1	237.1	0.18%	0.4
43541 ST MARYS	230	237.7	0.40%	1.0	239.0	0.41%	1.0
48023 BEACON N	115	115.2	0.23%	0.3	114.7	0.25%	0.3
46401 BOTHELL	115	118.5	0.06%	0.1	118.5	0.09%	0.1
46409 BROAD ST	115	116.9	0.07%	0.1	117.8	0.10%	0.1
45037 CAVE JCT	115	119.1	0.50%	0.6	121.6	0.43%	0.5
40205 CHEHALIS	115	117.5	0.31%	0.4	118.0	0.13%	0.2
46425 EASTPINE	115	117.0	0.52%	0.6	117.9	0.17%	0.2
40387 ELLENSBG	115	116.8	0.13%	0.2	116.7	0.14%	0.2
45121 GRANT PS	115	120.0	0.00%	0.0	120.3	0.00%	0.0
40633 LAPINE	115	119.3	0.49%	0.6	118.1	0.43%	0.5
46433 MASS	115	117.1	0.40%	0.5	118.0	0.10%	0.1
40765 MURRAY	115	115.4	0.45%	0.5	115.8	0.17%	0.2
40775 NASELLE	115	117.8	0.38%	0.4	118.5	0.13%	0.2
45255 PRINVILE	115	116.6	0.47%	0.5	116.9	0.42%	0.5
40897 ROSS	115	119.0	0.27%	0.3	119.2	0.21%	0.2
40921 SALEM	115	118.9	0.34%	0.4	118.4	0.36%	0.4
46087 SANDUNES	115	117.3	0.00%	0.0	117.0	0.01%	0.0
48383 SHAWNEE	115	115.9	0.20%	0.2	115.7	0.22%	0.3
42502 TALBOT	115	116.9	0.52%	0.6	116.9	0.14%	0.2
46449 UNION	115	117.0	0.52%	0.6	118.0	0.17%	0.2
46453 UNIVERSY	115	116.8	0.52%	0.6	117.6	0.17%	0.2
46455 VIEWLAND	115	116.7	0.39%	0.5	117.3	0.00%	0.0
41147 WHITE BL	115	118.5	0.11%	0.1	118.2	0.13%	0.2
42701 WHITE RV	115	116.8	0.49%	0.6	117.1	0.06%	0.1

Table 13: COI 2010 Winter LLH Voltage Change resulting from Dynamic Transfer

			09 HS pt1			09 HS pt 2		
			Volt (kV)	% Change	kV Change	Volt (kV)	% Change	kV Change
40045	ALLSTON	500	534.2	0.15%	0.8	534	0.15%	0.8
40323	CUSTER W	500	523.9	0.34%	1.8	521.9	0.37%	1.9
40381	ECHOLAKE	500	540.1	0.29%	1.6	540.2	0.30%	1.6
40459	GARRISON	500	537.8	0.23%	1.2	538.1	0.23%	1.2
40489	GRIZZLY	500	542.1	0.07%	0.4	547.1	0.07%	0.4
40687	MALIN	500	538.3	0.75%	4.0	544.9	0.74%	4.0
40699	MARION	500	542.7	0.04%	0.2	545.4	0.04%	0.2
45197	MERIDINP	500	545.3	0.33%	1.8	550.7	0.35%	1.9
40749	MONROE	500	544.3	0.13%	0.7	543.9	0.14%	0.7
40797	OLYMPIA	500	541	0.28%	1.5	541	0.30%	1.6
40821	PAUL	500	540	0.02%	0.1	540	0.02%	0.1
40827	PEARL	500	542.9	0.28%	1.5	543.7	0.29%	1.6
40869	RAVER	500	539.1	0.22%	1.2	539.1	0.24%	1.3
40957	SCHULTZ	500	542.9	0.18%	1.0	542.8	0.20%	1.1
41007	SNOKING	500	538.8	0.09%	0.5	538.9	0.13%	0.7
41043	SUMMER L	500	540.1	1.00%	5.4	546.1	1.00%	5.5
41051	TACOMA	500	537.7	0.02%	0.1	537.8	0.02%	0.1
41057	TAFT	500	540.7	0.09%	0.5	541.3	0.09%	0.5
41138	WAUTOMA	500	541.2	0.02%	0.1	540.3	0.02%	0.1
40059	ASHE	230	237.6	0.27%	0.6	237.4	0.28%	0.7
40095	BELLNGHM	230	237.6	0.27%	0.6	237.2	0.27%	0.6
40099	BENTON	230	229.6	0.06%	0.1	229.4	0.07%	0.1
40321	CUSTER W	230	238.9	0.12%	0.3	238.1	0.12%	0.3
40621	LAGRANDE	230	237.1	0.29%	0.7	238	0.31%	0.7
43313	MCLOUGLN	230	238.3	0.33%	0.8	238.6	0.36%	0.8
48255	N LEWIST	230	238.1	0.02%	0.0	238	0.02%	0.0
45249	PONDROSA	230	240.7	0.60%	1.4	239.7	0.60%	1.4
40851	POTHOLES	230	235.3	0.00%	0.0	235.1	0.00%	0.0
40875	RDMND_E	230	237.7	0.26%	0.6	238.1	0.26%	0.6
40883	RESTON	230	234.2	0.28%	0.7	235.1	0.29%	0.7
43459	RIVRGATE	230	235.7	0.67%	1.6	235.8	0.65%	1.5
40905	ROUNDUP	230	236.2	0.06%	0.2	237	0.06%	0.1
40939	SANTIAM	230	237.5	0.02%	0.1	237.5	0.02%	0.1
41328	SNOH S2	230	236.4	0.03%	0.1	236.6	0.04%	0.1
43541	ST MARYS	230	235.9	0.31%	0.7	236.1	0.33%	0.8
48023	BEACON N	115	115.7	0.39%	0.4	115.7	0.32%	0.4
46401	BOTHELL	115	118.3	0.37%	0.4	118.5	0.38%	0.5
46409	BROAD ST	115	116.4	0.00%	0.0	116.8	0.00%	0.0
45037	CAVE JCT	115	118.2	0.26%	0.3	118.2	0.28%	0.3
40205	CHEHALIS	115	117.8	0.03%	0.0	117.8	0.02%	0.0
46425	EASTPINE	115	116.6	0.37%	0.4	116.9	0.38%	0.4
40387	ELLENSBG	115	114.3	0.14%	0.2	114.1	0.14%	0.2
45121	GRANT PS	115	120	0.42%	0.5	119.9	0.41%	0.5
40633	LAPINE	115	118.1	0.35%	0.4	118.4	0.37%	0.4
46433	MASS	115	116.5	0.51%	0.6	116.9	0.53%	0.6
40765	MURRAY	115	115.8	0.01%	0.0	115	0.02%	0.0
40775	NASELLE	115	117.7	0.03%	0.0	117.6	0.03%	0.0
45255	PRINVILE	115	117.2	0.12%	0.1	117	0.13%	0.2
40897	ROSS	115	118.9	0.00%	0.0	119	0.00%	0.0
40921	SALEM	115	118.7	0.36%	0.4	118.8	0.37%	0.4
46087	SANDUNES	115	117.2	0.33%	0.4	117.1	0.34%	0.4
48383	SHAWNEE	115	115.8	0.30%	0.3	115.7	0.24%	0.3
42502	TALBOT	115	116.9	0.28%	0.3	117	0.29%	0.3
46449	UNION	115	116.4	0.25%	0.3	116.8	0.25%	0.3
46453	UNIVERSY	115	116.5	0.00%	0.0	116.8	0.00%	0.0
46455	VIEWLAND	115	116.5	0.00%	0.0	116.8	0.00%	0.0
41147	WHITE BL	115	117.8	0.06%	0.1	117.7	0.06%	0.1
42701	WHITE RV	115	117.2	0.28%	0.3	117.2	0.29%	0.3

Table 14: COI 2009 Summer HLH Voltage Change resulting from Dynamic Transfer

			09 HS pt 3			09 HS pt 4		
			Volt (kV)	% Change	kV Change	Volt (kV)	% Change	kV Change
40045	ALLSTON	500	533.2	0.09%	0.5	533.2	0.09%	0.5
40323	CUSTER W	500	523.1	0.38%	2.0	523.3	0.39%	2.0
40381	ECHOLAKE	500	538.6	0.28%	1.5	539	0.30%	1.6
40459	GARRISON	500	540.6	0.16%	0.8	539.8	0.16%	0.8
40489	GRIZZLY	500	541.6	0.06%	0.3	543.3	0.13%	0.7
40687	MALIN	500	538.6	0.74%	4.0	540.5	0.74%	4.0
40699	MARION	500	541.4	0.03%	0.2	543.4	0.10%	0.6
45197	MERIDINP	500	543.6	0.32%	1.7	545.4	0.33%	1.8
40749	MONROE	500	542.5	0.14%	0.7	542.9	0.14%	0.8
40797	OLYMPIA	500	541	0.33%	1.8	541	0.34%	1.8
40821	PAUL	500	540	0.02%	0.1	540	0.03%	0.1
40827	PEARL	500	542	0.26%	1.4	542.6	0.30%	1.6
40869	RAVER	500	537.9	0.25%	1.3	538.2	0.26%	1.4
40957	SCHULTZ	500	542.3	0.20%	1.1	542.2	0.21%	1.1
41007	SNOKING	500	536.6	0.16%	0.9	537.2	0.15%	0.8
41043	SUMMER L	500	540.5	1.00%	5.4	542.4	1.00%	5.4
41051	TACOMA	500	536.3	0.02%	0.1	536.7	0.02%	0.1
41057	TAFT	500	542.9	0.08%	0.4	542.2	0.08%	0.4
41138	WAUTOMA	500	540.8	0.06%	0.3	540.5	0.04%	0.2
40059	ASHE	230	237.6	0.25%	0.6	236.9	0.28%	0.7
40095	BELLNGHM	230	237.2	0.25%	0.6	237.3	0.28%	0.7
40099	BENTON	230	229.7	0.06%	0.1	228.9	0.13%	0.3
40321	CUSTER W	230	238.5	0.11%	0.3	238.6	0.11%	0.3
40621	LAGRANDE	230	232.5	0.32%	0.7	233.8	0.33%	0.8
43313	MCLOUGLN	230	238.1	0.39%	0.9	238.2	0.39%	0.9
48255	N LEWIST	230	236.6	0.02%	0.0	236.2	0.01%	0.0
45249	PONDROSA	230	240.7	0.56%	1.3	239.2	0.55%	1.3
40851	POTHOLES	230	235.2	0.00%	0.0	234.6	0.00%	0.0
40875	RDMND_E	230	237.5	0.24%	0.6	237	0.24%	0.6
40883	RESTON	230	232.9	0.26%	0.6	233.9	0.30%	0.7
43459	RIVRGATE	230	235.3	0.70%	1.7	235.5	0.70%	1.7
40905	ROUNDUP	230	232.4	0.01%	0.0	233.3	0.01%	0.0
40939	SANTIAM	230	237.1	0.02%	0.1	236.2	0.02%	0.1
41328	SNOH S2	230	234.8	0.03%	0.1	235.2	0.03%	0.1
43541	ST MARYS	230	235.5	0.35%	0.8	235.7	0.36%	0.9
48023	BEACON N	115	115.7	0.31%	0.4	115.7	0.33%	0.4
46401	BOTHELL	115	117.4	0.36%	0.4	117.6	0.37%	0.4
46409	BROAD ST	115	115.2	0.00%	0.0	115.6	0.00%	0.0
45037	CAVE JCT	115	118.4	0.30%	0.4	117.7	0.30%	0.4
40205	CHEHALIS	115	117.9	0.02%	0.0	117.8	0.02%	0.0
46425	EASTPINE	115	115.4	0.35%	0.4	115.7	0.36%	0.4
40387	ELLENSBG	115	114.2	0.09%	0.1	114	0.09%	0.1
45121	GRANT PS	115	120.2	0.44%	0.5	119.5	0.44%	0.5
40633	LAPINE	115	118	0.38%	0.4	117.7	0.39%	0.5
46433	MASS	115	115.3	0.49%	0.6	115.7	0.50%	0.6
40765	MURRAY	115	115.2	0.01%	0.0	115.5	0.01%	0.0
40775	NASELLE	115	117.4	0.03%	0.0	117.4	0.03%	0.0
45255	PRINVILE	115	117.2	0.14%	0.2	116.6	0.14%	0.2
40897	ROSS	115	118.8	0.00%	0.0	118.9	0.00%	0.0
40921	SALEM	115	118.6	0.34%	0.4	118.3	0.35%	0.4
46087	SANDUNES	115	117.2	0.32%	0.4	116.9	0.34%	0.4
48383	SHAWNEE	115	116.1	0.24%	0.3	115.9	0.26%	0.3
42502	TALBOT	115	116.5	0.27%	0.3	116.7	0.28%	0.3
46449	UNION	115	115.2	0.24%	0.3	115.6	0.24%	0.3
46453	UNIVERSY	115	115.3	0.00%	0.0	115.6	0.00%	0.0
46455	VIEWLAND	115	115.3	0.00%	0.0	115.6	0.00%	0.0
41147	WHITE BL	115	117.8	0.06%	0.1	117.4	0.06%	0.1
42701	WHITE RV	115	116.9	0.27%	0.3	117	0.28%	0.3

Table 15: COI 2009 Summer HLH Voltage Change resulting from Dynamic Transfer

All nomogram cases are voltage stability limited and the greater sensitivity to voltage is demonstrated in the lower dynamic transfer for COI. Note also the most limiting case being nomogram points 3 and 4, which are both modeling transfers into Idaho, a condition where the BPA system is most highly stressed.

Buses with the highest sensitivity are Malin, Summer Lake, Grizzly, and LaPine.

10 Heavy and Light Winter Cases	**Calculated Transfer Variation within Voltage Constraints**			
Interface Name	10 HW PT 1	10 HW PT 2	10 LW W12	10 LW W9
COI	299	358	523	464
NORTHWEST - CANADA	286	279	273	100
MONTANA - NORTHWEST	237	238	138	132
IDAHO-NW	330	332	168	162
NORTH OF HANFORD	456	454	262	293
NORTH OF JOHN DAY	510	507	374	255
SOUTH OF ALLSTON	369	367	136	282
WEST OF CASCADES - NORTH	414	409	235	276
WEST OF CASCADES - SOUTH	411	421	234	352
WEST OF MCNARY	165	165	96	101
WEST OF SLATT	317	316	173	201
Injection Group Location	MW	MW	MW	MW
NW Wind South of NJD (Columbia Gorge)	1655	1711	1207	1322
Northern California Hydro Generation	-186	-251	-500	-438
Westside Generation (Centralia)	-500	-500	-100	-459
BCTC Hydro	-286	-279	-273	-100
Idaho Generation (Bridger)	-500	-500	-234	-226
Montana Generation (Colstrip)	-183	-181	-100	-100

Table 16: Dynamic Transfer calculated from ∂V/∂P and 1% voltage constraint

09 Heavy Summer Cases	**Calculated Transfer Variation within Voltage Constraints**			
Interface Name	09 HS PT 1	09 HS PT 2	09 HS PT 3	09 HS PT 4
COI	231	293	190	194
NORTHWEST - CANADA	300	300	300	300
MONTANA - NORTHWEST	225	231	229	232
IDAHO-NW	327	330	242	255
NORTH OF HANFORD	459	463	454	456
NORTH OF JOHN DAY	510	517	501	505
SOUTH OF ALLSTON	372	372	372	373
WEST OF CASCADES - NORTH	425	425	424	424
WEST OF CASCADES - SOUTH	400	413	383	386
WEST OF MCNARY	163	166	155	157
WEST OF SLATT	316	319	308	310
Injection Group Location	MW	MW	MW	MW
NW Wind South of NJD (Columbia Gorge)	1586	1657	1462	1483
Northern California Hydro Generation	-113	-180	-100	-100
Westside Generation (Centralia)	-500	-500	-500	-500
BCTC Hydro	-300	-300	-300	-300
Idaho Generation (Bridger)	-500	-500	-349	-371
Montana Generation (Colstrip)	-173	-177	-214	-212

Table 17: Dynamic Transfer calculated from ∂V/∂P and 1% voltage constraint